# AUTOMATION

AUGUST 1956

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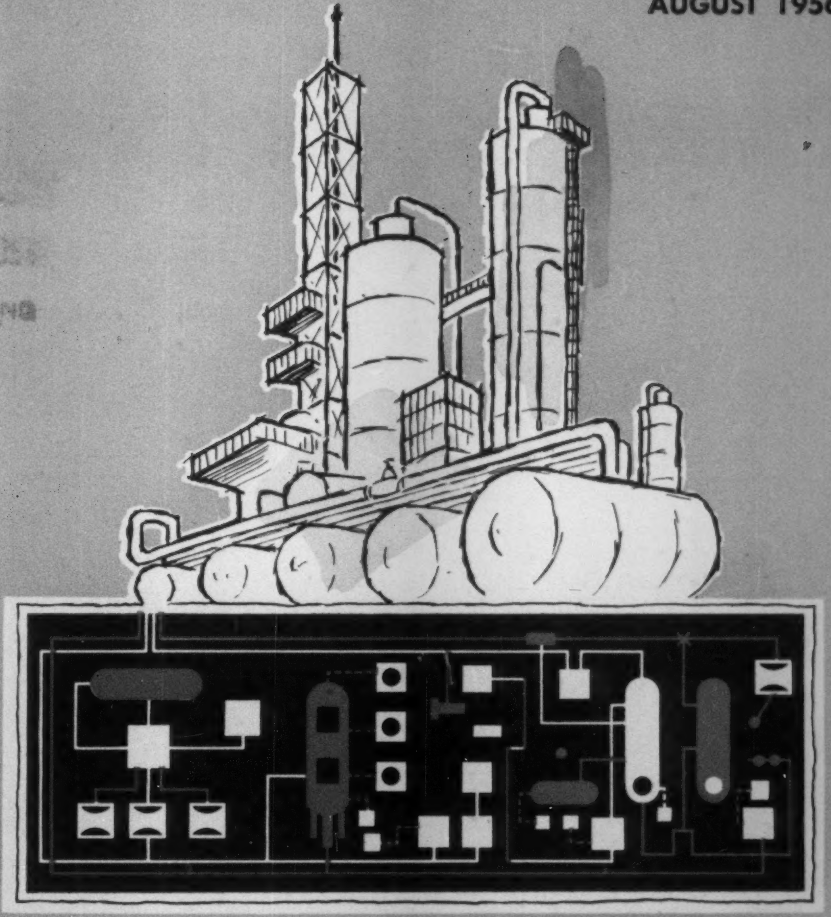

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### The Magazine of Automatic Operations

- ▶ **Electronic Reliability**
- ▶ **Evaluating Machine Arrangements**
- ▶ **Photocells Control Press Brake**
- ▶ **Electrohydraulic Handling System**

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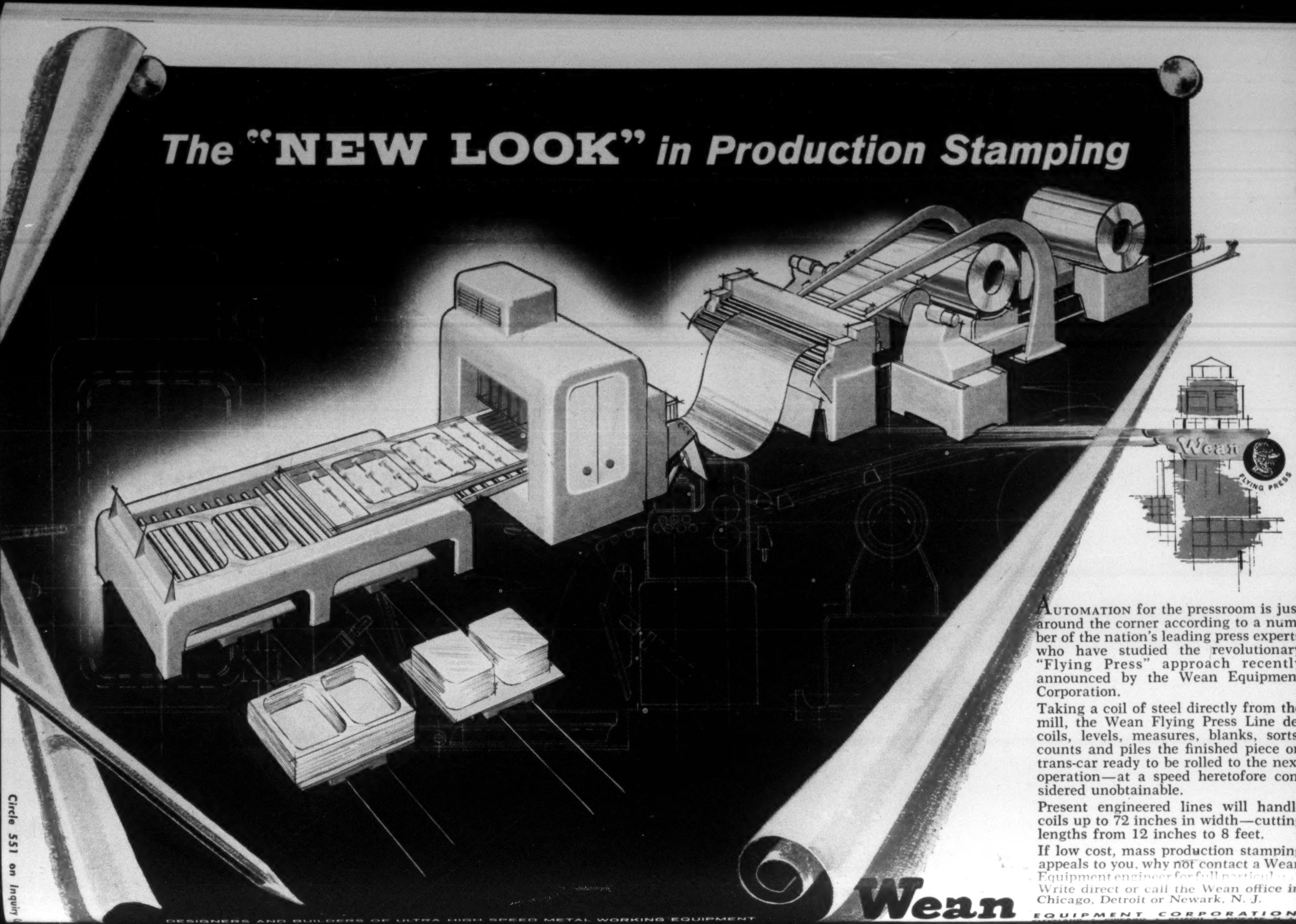
# The "NEW LOOK" in Production Stamping



AUTOMATION for the pressroom is just around the corner according to a number of the nation's leading press experts who have studied the revolutionary "Flying Press" approach recently announced by the Wean Equipment Corporation.

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AUGUST, 1956
Vol. 3—No. 8

AUTOMATION ®

*THE MAGAZINE OF AUTOMATIC OPERATIONS*

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# automation outlook

## LABOR WELCOMES AUTOMATION

". . . organized labor is not afraid of the new technological development called automation. Indeed, organized labor welcomes automation. The new technology offers the promise of improved living conditions and greater leisure for all, increased national strength and more pleasant working conditions. It promises the elimination of most routine and repetitive jobs . . ."—*George Meany, president, American Federation of Labor and Congress of Industrial Organizations.*

## MANAGEMENT SEES ADVANTAGES

". . . with individuals circulating through the economy this way—even as blood circulates through the human body, constantly revitalizing and renewing the tissues—it can be seen that the (labor) changes resulting from automation are negligible and far outweighed by the advantages that will accrue to the whole of America as the result of increased productivity. More goods made for more people by fewer workers is the necessary order of things in the future when, because of our higher birth rate and the prolongation of human life, a correspondingly smaller number of men and women are doing the essential work of the world. . ."—*Cola G. Parker, president, National Association of Manufacturers.*

## WANTED BY THE STEEL INDUSTRY

". . . a system which could continuously monitor the (electrolytic tinning) coating thickness with X-ray or nuclear radiation gages and control coating thickness by regulating the plating power source . . .

". . . complete automation of the welding operation. This would reduce the time required to make a weld, thus contributing to improved quality by permitting uniform speed of operation for longer periods of time. . .

". . . an automatic length assorting device is needed . . .

". . . complete automation of inspection and classification of defects could contribute to even further improved quality . . . " — *W. K. Scott, United States Steel Corp.*

## NO INDICATION OF SLOWDOWN

". . . there has been no indication as yet of a slowdown in industrial expansion and retooling to secure the tools of automation which all industries are finding they require to meet the intense competition that exists now and will exist for many years to come . . ."—*J. W. Corey, president, Reliance Electric & Engineering Co.*

## EQUIPPED WITH AUTOMATION

". . . today's machine tools, properly equipped with automation, have enabled us to provide safer and healthier working conditions for our employees, and at the same time have much improved our economy. We are also getting better quality. In some cases, as many of you know, we have been able to build quality control gages right into the machine tools. We are now able to utilize our machines more effectively. The machine tool industry will keep pace, if it doesn't lead the way, in engineering and building machine tools which will enable industry to produce the goods to satisfy our increasing population with its rising standard of living in spite of the relatively small increase in the labor force . . ."—*Ray H. Sullivan, vice president, Ford Motor Co.*

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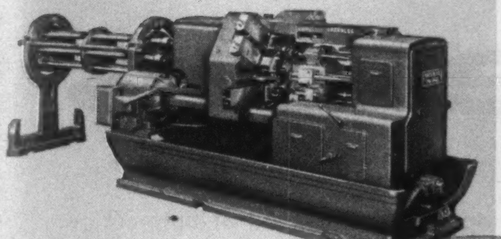

Greenlee Six-Spindle Automatic Bar Machine.

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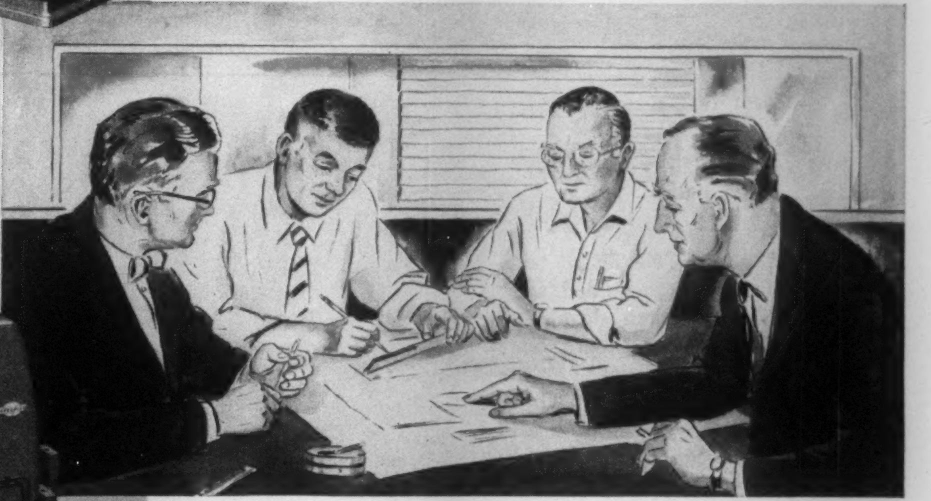
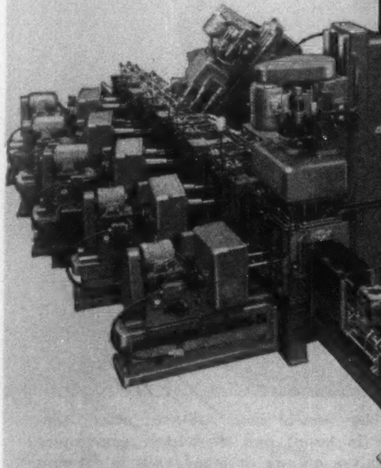


Greenlee 22-Station Automatic Transfer Machine for machining transmission cases.



Greenlee creative thinking, Greenlee engineering and Greenlee experience combined with that of your own engineers will help you "produce more at lower cost."

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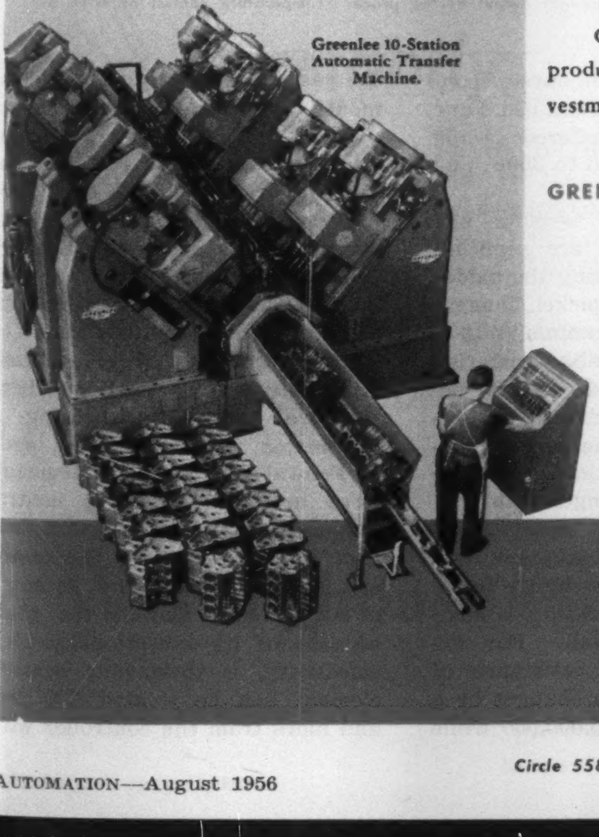

Greenlee 10-Station Automatic Transfer Machine.

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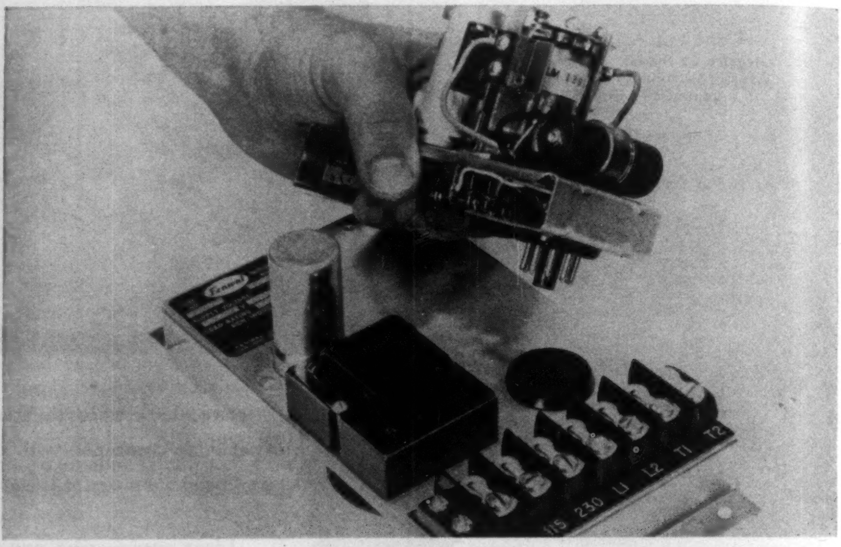
# AUTOMATION news

Today's events and developments in the field of automation

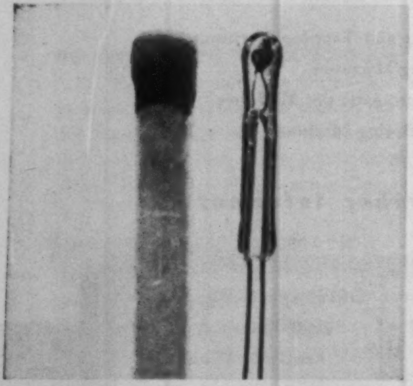
## Plug-In Temperature Controller Uses Precision Thermistors

THERMISTOR-ACTUATED temperature controller, designed as a plug-in unit, has been developed by Fenwal Inc. The controller consists of three elements: (1) the plug-in control unit—containing the control circuitry, amplifier and relay on a chassis approximately 2½ by 7 inches; (2) a power supply on a separate chassis—containing the power transformer, terminal strip and socket to receive the male plug from the control unit; and (3) a thermistor temperature sensing probe.



COMPACT temperature controller developed by Fenwal Inc., Ashland, Mass., consists of a power supply, plug-in control unit (in hand) and thermistor temperature sensing probes. Building block design permits use of one or many units in forming system which can be located up to 200 ft away from probe, with negligible reduction in the signal strength output of the probe. Temperature control of ±1F or better is possible.

A system for controlling temperatures at multiple points can be set up conveniently and economically simply by grouping the required number of control units onto a single power chassis. The electronic circuitry is relatively simple, and because components carry only a small fraction of their rated capacity, the unit can be expected to give 10,000 hours of continuous service in normal use. Four control ranges are offered: −100 to 50F, 0 to 50F, 100 to 300F, and 200 to 600F.



SMALL size of bead type thermistor is emphasized in comparison to head of match. The bead is normally encased in glass for protection. Precision thermistor probes are also made in rod, disk and washer shapes to suit specific requirements.

The temperature sensing elements, thermistors, are semiconductors made by fusing the oxides of such metals as nickel, manganese, cobalt and uranium, into a hard dense ceramic-like material. The name thermistor, a contraction of "thermal resistor," designates one of the thermistor's important characteristics: Its electrical resistance changes with temperature. Although many semiconductors and metals have this same property, their change in resistance with temperature is comparatively very small. For example, the specific resistance of thermistor materials changes by a factor of 1000 to 10,000,000 while the resistance of platinum, a commonly used temperature sensitive element, changes by a factor of less than 10 over the same temperature range. This extraordinary sensitivity of the thermistor permits it to respond to extremely small temperature changes, so that it can be used to measure temperature with an accuracy of 0.001-degree or better. For standard industrial applications, temperature controllers utilizing a thermistor sensing element, such as Fenwal's Series 560 instrument, have been developed to control temperature within 1F. Concomitant advantages of the thermistor are its small size (some as small as a pin head), and the fact that, because of its exceptionally high sensitivity, a thermistor sensing element can be located 200 feet and more from the controller with

## New DynAC® stops motors *instantly*...without a ripple!

Here's dramatic proof of the smooth, controlled braking action of the new Westinghouse DYNAC braking controller. Motor stopped *instantly*—without disturbing the water in the glass goblet. "Grabbing" or jerky stops are eliminated with DYNAC braking.

Wherever rapid and/or controlled stopping is required, DYNAC can not only contribute an important safety factor, but it can save you headaches—*and money*—on: (1) production time, (2) material rejects and spoilage, and (3) maintenance expense.

Because it's *completely* electrical, DYNAC requires no mechanical apparatus or motor linkage—it simplifies maintenance. And it comes in *one* compact, spacesaving enclosure. Get the facts on DYNAC's many cost-cutting applications—with every type of standard induction motor. Use the coupon below for more information on DYNAC.

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little or no reduction in the working signal.

Another property, unique to the thermistor, has led to a number of interesting and far reaching applications. The property is its current-voltage characteristic. When a thermistor is incorporated into an electrical circuit, and the current is allowed to exceed a certain amperage, the voltage through the thermistor is no longer proportional to the current, but drops off with further increase in current. This phenomenon makes the thermistor highly useful for applications involving automatic voltage regulation, amplifier gain control, temperature alarms, contactless switching action, etc. Since this voltage drop-off is a function of decreased resistance of the thermistor due to self-heating, applications can be based on the amount of heat that the thermistor can dissipate to its environment. This opens up a new technique of instrumentation for the detection or measurement of fluid flows, liquid level, thermal conductivity, and other variables which produce a cooling or heat effect around the sensing element.

The third important property of thermistors is the current-time characteristic. Depending on the material, a thermistor will require from a few milliseconds to several minutes before the current through a thermistor reaches its final level. Using a thermistor having the appropriate time delay therefore provides a simple means of designing equipment requiring specific time delays without complex circuits or costly equipment. Such an application has eliminated a problem of false ring-ups in telephone circuitry caused by transient disturbances. A thermistor placed in series with the ring-up relay delays operation of the relay for a period long enough to screen out the transient signals.

ANNOUNCEMENT of the merger of Hydraulic Press Mfg. Co., Mount Gilead, Ohio, into the Koehring Co., Milwaukee, has been made by **Julien R. Steelman**, president of Koehring. **G. B. Robinson**, chairman of H-P-M, has been named to the Koehring board of directors. No changes in the management or policies of H-P-M are contemplated, and the company will be operated as a division of Koehring.

H-P-M is a manufacturer of metalworking presses, plastic injection molding and die casting machines, hydraulic components and metal baling and steeping presses. The merger, according to Steelman, will permit Koehring Co., a major producer of construction equipment, to further diversify markets for its products. Since World War II, the company's sales potential has been boosted by new products introduced for railroad maintenance of way work, pipeline equipment, heating and pressure boilers, pulp grinding and processing equipment, fork lift material handling units and open pit mining machinery.

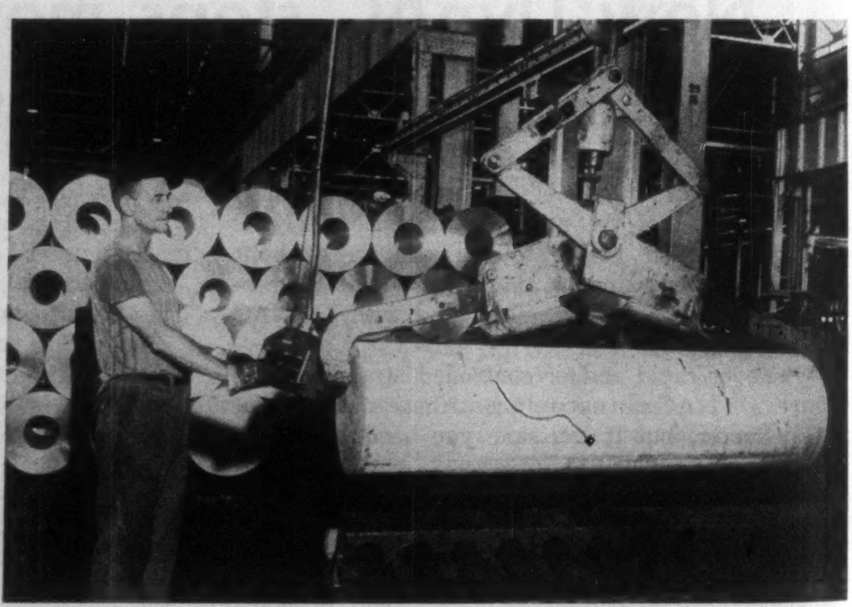
## Unique Swiss Pipeline

FIRST pipe line has been installed in Switzerland—not for the transport of oil or gas—but milk. Transportation of milk from mountainous regions to the creameries in the valley presented a major problem to some producers in the Canton of Valais. The first experimental line is already in operation, and consists of plastic noncorrosive tubes placed underground where possible. The tubes are cooled by an intermittent flow of cold water, stopped several times a day to allow the passage of milk. The changeover from cold water to milk is regulated by a telephone system connecting two ends of the line.

## Self-Checking Circuits Insure Safe Operations

NEW monitoring technique, which checks itself by a pulsation method, has been developed by the Scully Signal Co. of Melrose, Mass. Invented by **William G. Rowell**, Scully chief engineer, the system requires few additional components to change conventional static control systems to a dynamic self-checking design. The technique is sufficiently basic to be used with electronic, electrical, mechanical, pneumatic, hydraulic, and nuclear systems.

Fields of application include fire protection, industrial and home



IN ANSWERING the question as to the best way to handle cylindrical aluminum ingots designed for extruding in a 14,000-ton press of the Aluminum Co. of America, automatic tongs built by the Heppenstall Co. of Pittsburgh were adopted. Typical of the method used is this view of the Heppenstall automatic tongs placing a 785-lb ingot on a conveyor which feeds a manipulator at the heating station serving the giant extrusion press. The tongs, which eliminate need for hands to touch the ingots, have a variable opening which allows use with ingots from 15 to 72 inches in length.

Schrader 4-way SOLENOID OPERATED VALVE is the heart of the sealing operation shown in this photograph. Hundreds of other Schrader products adapt to almost any manufacturing hookup. A few of them are indicated here in red (Numbers 1 through 6).

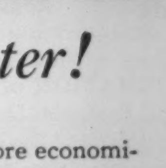
# How Schrader Air Products help seal

# *5000 pellet boxes per day–3 times faster!*

Box sealing is a common operation performed by compressed air. Just how speedy it can be is demonstrated at a New York arms manufacturing plant, where 5000 boxes of pellets are crimped tight each day. The back-breaking job of crimping by foot power is eliminated, and the operator does not become fatigued.

Wherever operations are automated—in holding or positioning work, moving scraps or chips, or synchronizing actions—air can help. By making these steps automatic, more efficient manufacturing is achieved.

In many cases this can be done more economically with Schrader Air Products than in any other way. Upon request, Schrader engineers will assist you in planning for the most efficient use of air and in selecting the products best suited to your applications. Outline your problem to us . . . we'll be glad to help you. Or, send for the latest informative booklets which show Schrader Air Products that will help you increase production—economically.



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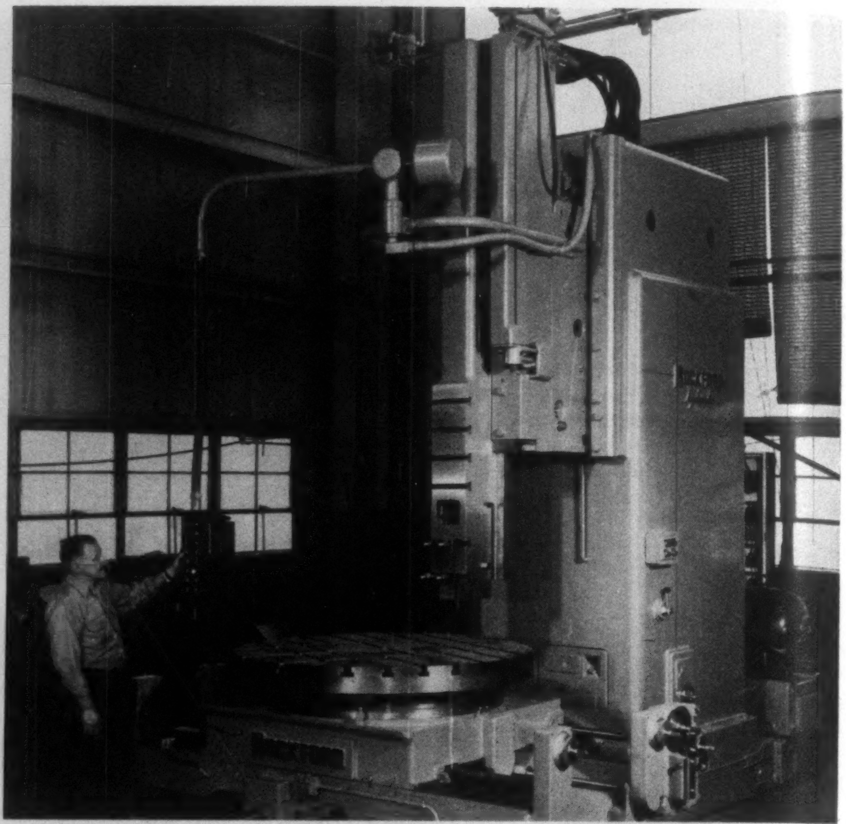


HYDRAULIC slotter has been developed by Rockford Machine Tool Co. Unit is built in sizes for either 36 or 48-inch stroke lengths. Hydraulic drive provides for two speed ranges, with cutting speeds infinitely variable from zero to maximum in either range. Hydraulic feeds may also be varied infinitely from zero to maximum and no levers are required for engagement of any feed or traverse movement. Position of upper and lower reverse dogs on the ram may be changed from a push-button station to enable operator to lengthen or shorten the stroke.

heating control, railroad, aircraft and safety systems, and process control instrumentation.

Equipment protective devices and system monitors incorporating the new method continually check themselves by periodically simulating the dangerous (unsafe) condition they are designed to detect. If the protective monitor responds properly to this simulated danger, it is sure to respond to the real danger when it occurs. An alarm suppression circuit is built into the monitor to hold off the warning signal during the short period of simulated danger.

The simulated unsafe condition is introduced periodically into the monitor, resulting in a continual safe-unsafe-safe-unsafe, etc., oscillation which holds the alarm off. Failure of the safe condition being sensed or of the monitoring system itself halts the required safe-unsafe oscillation and sounds the alarm or initiates corrective action.

The safe-unsafe oscillation may be caused by a free-running perturbation device at the monitor input, or by the use of feedback to produce a relaxation oscillation within the monitoring system. The period of oscillation can be adjusted to meet the requirements of the particular control system, and may range from hours to microseconds.

---

FORMATION of a Data and Control Systems Dept. has been announced by Beckman Instruments Inc. The new group was created in response to the ever-growing need for a separate unit primarily interested in automatic data processing and the ultimate linking of instrumentation with digital computers.

The new department, managed by **Taylor C. Fletcher,** previously manager of Beckman's Industrial Instruments group, is presently working on two new data systems; one is a system particularly developed for chemical processing, petroleum refining and other similar industries where process monitoring and measuring can vary from one to ten samples per second. The other is Beckman's high speed sampling system. As many as 1000 channels can be sampled at rates of 1000 to 2000 channels per second. The new department will also design, manufacture and sell data components in addition to complete systems.

## Proposed Conveyor Application Will Generate Electricity

CONVEYOR system that will also generate electrical power will be built to move 30 million tons of gravel from a Utah hill into the Great Salt Lake. The gravel will be used in constructing a 13-mile roadbed for the Southern Pacific railroad across the lake.

The conveyor system, being designed and manufactured by Hewitt-Robins Inc., is nearly two miles long and will handle the gravel at an average rate of 75,000 tons a day. When operating at full capacity, the rate can be increased to 90,000 tons, working three shifts totaling $21\frac{1}{2}$ hours. The speed of the belts will be 800 feet a minute, exceeding usual belt speeds by 300 to 400 feet a minute.

The main part of the conveyor system will require little or no power from outside sources once it gets rolling. This is because the conveyors will coast downgrade from the gravel hill to the lake. The three motors attached to the three main conveyor units will function as a braking system to regulate the speed of descent. The energy created by the gravitational glide will be converted into electrical power by the motors which in effect will become electrical generators. The wiring system will be arranged to capture this surplus power and feed it to three electric shovels to supplement the power required in digging the gravel out of the hill. Engineers estimate that the amount of surplus electricity generated by the three regenerative motors will be about 618,000 watts an hour. The difference in height between the gravel hill and the lake is 400 feet. The gravel will be put through a screening and crushing process to reduce all lumps to 8 inches or under before it is fed onto the 54-inch wide conveyor belts.

After the downhill ride of a little less than two miles, the material will be transferred to a stacking conveyor which can build a storage pile up to 70 feet high. Under the pile will be two tunnels, a conveyor running through each one. These conveyors will be 72 inches wide and will have a combined capacity of 12,000 tons an hour, running at 550 feet a minute. The material will be fed to the tunnel conveyors by a series of overhead feeders to control the rate of flow to any tonnage desired. These conveyors will carry the material about 250 feet to the edge of the lake and dump it into barges of which there will be seven shuttling back and forth between the discharge point of the conveyors and the new roadbed.

## Instrument Measures Liquid By Continuously Weighing Flow

DEVICE which measures liquid or gas by weighing it continuously as it passes through a pipe is manufactured by Industrial Instruments Inc., Santa Monica, Calif. It represents one of the latest applications of Ni-Span C, a "constant-modulus" alloy processed by the H. A. Wilson Co., Union, N.J.

Though developed primarily for use in jet aircraft fuel systems, it has been found ideal for such jobs as measuring the amount of liquid water in a steam line, the degree of froth in engine oil, and the proportions of a mixture of helium and oxygen. It is solving special measurement problems in guided missiles, laboratory test equipment, pipelines, petroleum refineries, and other continuous process industries.

The flowmeter, housed in a single sturdy assembly not much larger in diameter than the fuel line itself, weighs the fuel directly. It is accurate within ±½ of 1 per cent, due to its method of operation and to the elimination of temperature errors through the use of Ni-Span C for all elastic parts.

As liquid passes through the flowmeter, it is given a precise angular velocity by an impeller. Then a measuring turbine subdues this velocity completely. Since the original angular acceleration is constant and known, the torque necessary to subdue the liquid's velocity is a measure of the mass which was accelerated—the "mass flow." The torque of the measuring turbine activates a calibrated spring. The spring's deflection is converted into an electrical signal by an output transducer. The signal registers on a dial indicator, a digital counter, and/or a totalizer. Through the use of Ni-Span C, the transducer assembly's overall thermoelastic coefficient has been held to 50 parts per million per degree F. That of the spring itself is considerably better.

The flowmeter is suitable for use in feedback process control applications because of its accuracy, the convenient form of its output signal, and the fact that the frequency response of the standard model is flat to approximately 7 cps. Special designs are also available with a flat frequency response out to as high as 10 cps.

---

RECENTLY elected president of Fluid Controls Institute Inc. is **John C. Koch,** vice president and general manager of Conoflow Corp. Fluid Controls Institute Inc., formerly the National Steam Specialty Club, is a trade association for manufacturers of industrial control valves and regulators. Koch is president of the Philadelphia section of the Instrument Society of America and is active on several national ISA committees. He is also a member of the Engineers Club of Philadelphia.

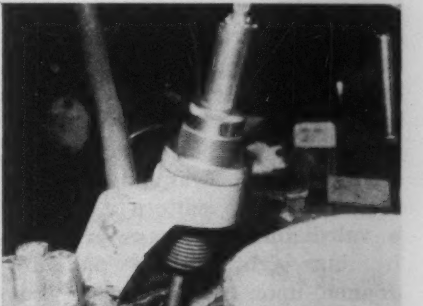
## Urges Stockpiling Of Pushbutton Potential

GEARING the nation's defense industries to meet emergency demands requires stockpiling of "pushbutton potential" in the form of a reserve of readily expandable automated precision capacity, according to **W. Fay Aller,** vice president and director of research of the Sheffield Corp. Before a joint meeting of defense industry advisory committees in Washington, he said, "Our big challenge—and responsibility—in the machine tool industry is to work as hard as we can to keep ahead of the most rapid conceivable rate of obsolescence in military weapons. That responsibility naturally propels us into planning the automated defense production plant of the future and doing so at full speed ahead and in the fullest detail our knowledge and vision will permit."

Aller pointed out that while there may be "honest differences of opinion as to the imminence of a total pushbutton war," the fact remains that the volume demands of any military emergency require that we equip ourselves now with a pushbutton production potential in order to offset both time and manpower shortages.

"In military production, both the armed forces and science and in-

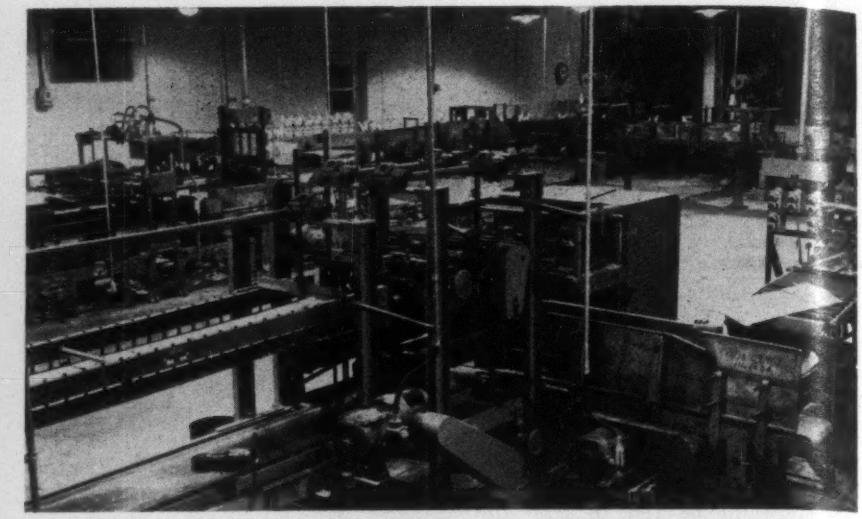
DIFFERENTIAL transformer measuring head and related control equipment provided by Automatic Temperature Control Co. Inc. are used by bearing manufacturer in obtaining increased accuracy and quantity of production in a grinding operation. Rough ground spherical rollers are loaded and grinding operations initiated manually. Upon switching to automatic feed, stock removal is continuously sensed by the measuring head and feed is stopped at a set point above final grinding dimension. After a timed dress-up operation, the control actuates withdrawal and stops spindle motor. With the automatic control of feed, part tolerance is in the 3-5 micron range.



dustry are faced with the challenging fact that anything we stockpile today may be obsoleted tomorrow, or a year from tomorrow by the almost supersonic speeds of weapons, technology, research, design—and yes, competition of the most compelling and rigorous kind.

"And because this rapid rate of progress extends comparably to metallurgy, tools and methods, we must resolutely face the fact that we can stockpile a very few of the tools we may require in emergency to step up to high volume, high precision production under the split second urgency of a possible pushbutton conflict."

The Sheffield research executive, whose company specializes in development of precision tooling, gaging and devices and automatic control units and systems, stressed that "consumer industries, already taking their first steps toward automation as a matter of competitive survival, are setting the pace and pattern" for defense industries to follow.



MODERN dog food plant processes ingredients from unload point to packaging in completely automated setup. Standard-Knapp packaging equipment is shown in the foreground of the picture of Kasco Mills' new National City, Ill. plant. The automated facilities allow the processor to work to closer production schedules, thereby making it unnecessary to store large inventories. At the present time a total work force of nine people turn out nine carloads of dog food daily.

## Youth Sees Challenge In Increasing Automation

TO THE CHILD and parent alike, a June graduation can be a wonderful experience. Both can share the pride of accomplishment in successfully reaching an identifiable goal along that path of youth developing into adulthood. And for youth, traditionally, the valedictorian address at graduation time offers an opportunity to express the idealism of their age. One of AUTOMATION's readers, **K. N. Banthin,** supervisor of construction and maintenance, Food Casing. Div., Visking Corp., was kind enough to send to the editors a copy of a valedictorian address presented by his eighth grade daughter, Joanne, upon her graduation from the Edmund F. Lindop School, Broadview, Ill.

The general theme of the valedictory speeches was "the election year and how it would affect our graduating class." Within the framework of this general theme, Joanne chose automation as a subject for her address—a decision which was influenced by old copies of AUTOMATION Magazine which her father keeps on his desk at home. With the help of her teachers, Joanne prepared the following speech:

"This year, as you know, is an election year. It is your duty as well as your privilege as parents to vote. The issue of automation has come up in the present administration, and it will come up in the campaign.

" If you elect officers that believe that as much as possible should be done by machines, they will encourage research in that field, and they will do things to get young people, perhaps some of our class, interested in work toward the advancement of automation. If you elect officers that have thinking opposite to this, we, as a nation may find ourselves in a similar position to that of our forefathers of a hundred years ago, in the dawn of the industrial revolution.

"Automation affects, or will affect all businesses, from big industry to the young man that earns extra money as a pinboy.

"Manpower has a new meaning now. The circle is almost complete. The cycle has run its full round—or will have within the next decade. With the industrial revolution the machine assumed towering importance. Mass production now dominates the scene. The conveyor belt has taken over from the hands of the artisan.

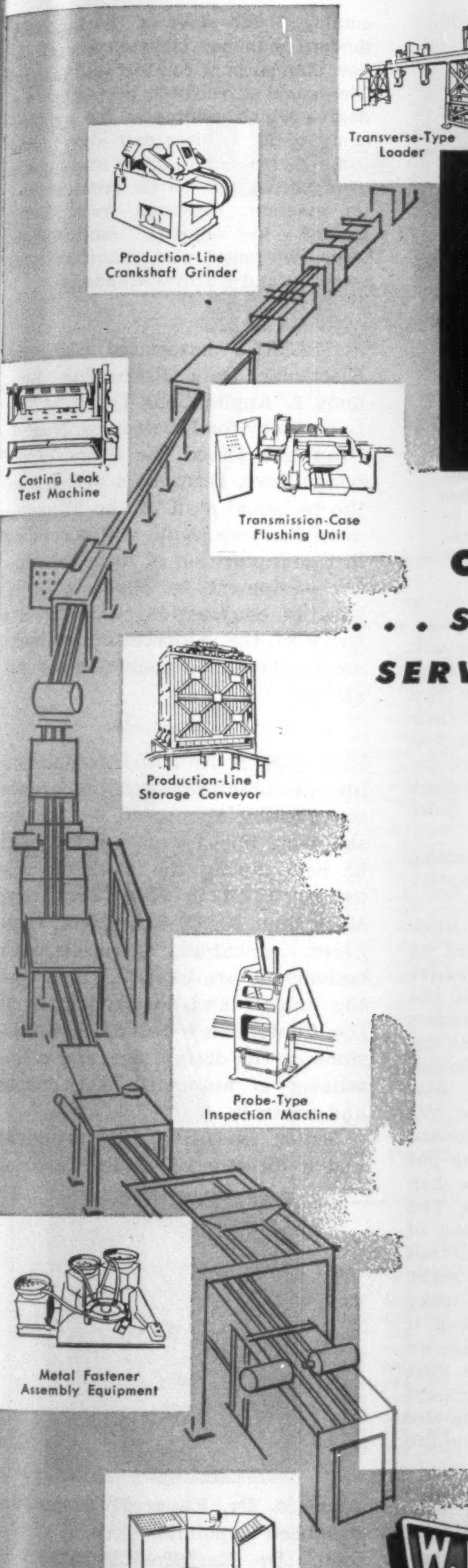
"What all this meant to manpower was simple: The nation needed vast quantities of unskilled labor. The success of the industrial revolution at this time depended on the investment of capital—on the money that would build the factory, finance the assembly line, and construct and buy the machine. The investment in human beings at this time was relatively unimportant. Manpower was almost entirely a question of quantity not of quality.

"When a machine broke down, several mechanics would be sent out to work on the same machine. Now, a single mechanic, who is more specialized and has more technical knowledge can do the same type of job in the same amount of time. If the mechanic of 15 years ago was told to repair one of today's machines, he would probably become hopelessly confused. Training today is more technical and advanced. It has to be, to keep up with the more technical machines of today.

"Perhaps some of us on this stage will think of new and cheaper ways to manufacture industrial equipment, which in turn will make necessary goods cheaper. Maybe one of us will think of ways to use atomic power for industry, or, we may think of something new and completely different.

"With each step forward, the need for highly trained, highly educated, and highly skilled manpower has increased. It is up to you, the parents, as well as us, to see that we get the proper education for the future. Twenty years ago a college degree was not necessary. Now it is needed for many jobs, and desirable for many more.

"The way we have been talking, you'd think that engineering was the only occupation that automation affects. This is far from true. Girls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Transmission-Case Flushing Unit
Production-Line Storage Conveyor
Probe-Type Inspection Machine
Metal Fastener Assembly Equipment
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More and more production executives than ever before are today turning to Barnes for help in designing and building specialized automation equipment. With 80 years of practical machine building experience, Barnes have been called upon to design and build hundreds of different types of automatic handling and special processing equipment as well as special high production machine tools. Now, to better serve demands and help you solve automation problems quickly, Barnes offers a two-fold coordinated service:

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If you are planning new production-line methods for either automatic or semi-automatic operations, an experienced engineering staff is available to work with you. The detailed plans and proposals submitted for your consideration can be depended upon to provide you with the latest in automation engineering and the very best of proven mechanical, hydraulic, and electrical actuation. Ask for a free survey of your problems early in your planning program.

### DESIGNING & BUILDING SPECIALIZED UNITS

2

Designing and building specialized, individual units to suit your specific needs is a separate, additional service. Where required, electrical, mechanical, hydraulic, fixture, and tool engineers work together as a team. All efforts are closely coordinated with complete manufacturing facilities to save you time and eliminate divided responsibility. As illustrated, this service covers hundreds of different types of automatic processing and work-handling units that are today profitably serving a wide range of industrial needs.

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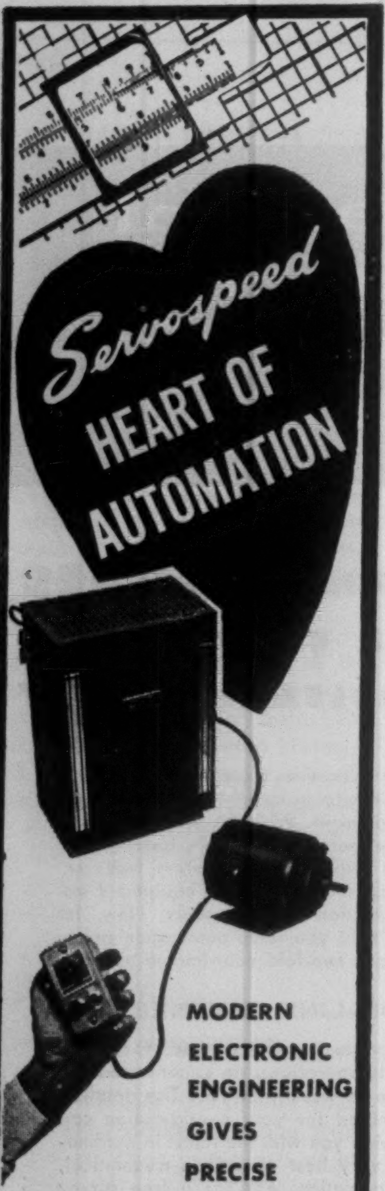
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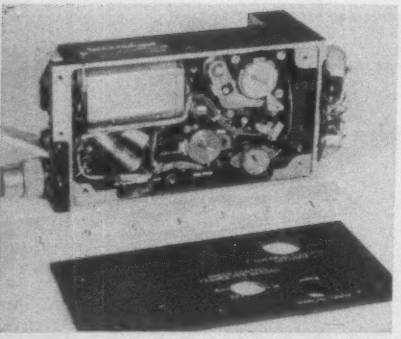

LIGHT received through picture taking lens of new aerial gun camera is compared 64 times a second with illumination from reference lamp inside camera. If there is a difference, control system contained in camera automatically adjusts lens diaphragm to ideal setting. System can adjust through six lens stops in 1.8 seconds. Manufactured by Fairchild Camera & Instrument Corp., the camera is designed for installation on jet fighter planes.

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who wish to become secretaries will find automation a real force. The work that used to be done by two to four secretaries is now being done by one operator, and the help of machines. Many machines that were unknown, or in the experimental stage when you were our age are quite common in offices today.

"Because of these various machines, there will be a demand for a highly-trained operator.

"We have been talking about automation in industry and business up to now. But, perhaps the place where automation is most evident is in the home. If you compare the kitchen of the home in which you spent the early part of your life to the kitchen you have today, you realize how many changes have taken place. We have many things now that make the life of the housewife easier. You put the toast in the popper, set the dial, and wait for the toast to pop. You use an automatic mixer instead of a hand beater, and a vacuum instead of a carpet sweeper. You use many things without realizing how lucky you are. You, our parents, have it easier than your parents, and we will probably have it still easier. Just as someone on this stage may invent a machine for industry, someone else may invent a device to make the life of the housewife easier.

"As we are approaching the last stage of this modern industrial revolution—automation—the picture has changed dramatically. Mass production and mass distribution have led to an economy of plenty. At this rate you'd think that man would have put himself out of work. But he hasn't. He has, instead, created new jobs; jobs in the fields of science and all kinds of engineering. Far from becoming a dull slave of the machine, modern man has elevated himself to new standards of comfort and leisure. The machine has been perfected to a degree which eliminates the original army of its tenders and slaves and demands instead an army of men and women that can be its creators and its masters. Although we're being trained to support materialistic ideas, we must also maintain high spiritual and cultural standards."

---

FORMERLY associated with the Electronic Data Processing Systems & Applications Dept. at the Laboratory for Electronics, **Neal J. Dean** has joined the Ramo-Wooldridge Corp. Dean, as a member of the technical staff of the Management Sciences Dept., will specialize in the application of data processing equipment to business problems in conjunction with the activity of the department as technical consultant to business organizations.

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ELEVENTH Annual International Instrument-Automation Conference and Exhibit sponsored by the Instrument Society of America will be held during the week of September 17-21 in New York city. More than 30,000 executives, engineers, educators, scientists and technicians are expected to attend the exhibit and to participate in the Conference's technical discussions on the design, use, and maintenance of automatic instruments and controls.

Senior executive vice president and a director of Radio Corp. of America, **Dr. Elmer W. Engstrom** has been appointed general chairman. Dr. Engstrom is known in industrial circles for his direction of RCA's laboratories which have contributed much in the field of electronics, radio, communications and television. Assisting the general chairman as joint executive

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*Keep Up-to-Date!*

chairman of the ISA host committee are Hamilton R. Bristol of the Bristol Co. and Carl W. Gram Jr. of the Mason-Neilan Regulator Co.

### New Printed Circuit Process

PREPARATION of printed electrical circuits for etching can now be done by xerography, the Haloid Co., Rochester, has announced. The new process promises considerable savings in time and money for model shop work, prototype circuit studies, and short production runs.

In the new application, the powder image peculiar to xerography—a fast, dry, electrostatic method of copying, heretofore used chiefly in office and graphic arts reproduction—is transferred from a XeroX selenium plate to a sheet or transfer paper, thence to the face of a copper-clad laminate. Here the powder forms an exact resist pattern impervious to chemical attack.

Since, in the etching step which follows, acid eats away all the copper unprotected by resist, the result is metal left only where specified by the original circuit drawing. The zerographic powder or resist, having accomplished its purpose, is then removed by solvent, disclosing the completed print ready for dip-soldering to pigtails or other contacts.

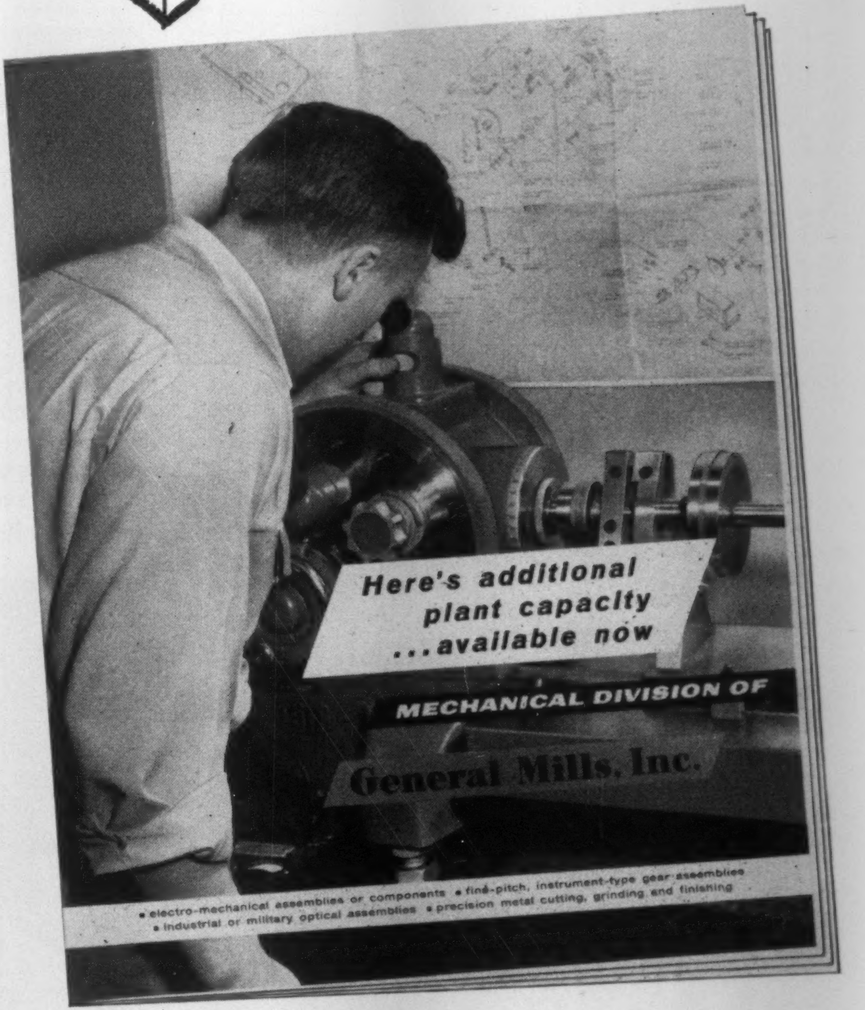
From an original opaque drawing, a copper-clad laminate serving as a printed circuit or wiring board can be prepared for etching in about 10 minutes. Except for the final etching step, the xerographic approach is entirely dry, requiring neither conventional photographic materials nor darkroom facilities.

### Servo System Provides Automatic Throttle Regulation

AUTOMATIC control system which operates aircraft engine throttles during landing approach has been developed by the Safe Flight Instrument Corp. The basic instrument system is an open loop servomechanism system which provides continuous rate and trend informa-

*Free booklet tells how to...*

**Add our brains and machines to those you have now...**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MECHANICAL DIVISION OF
General Mills, Inc.
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*You can avoid* the pitfalls and problems of plant expansion, yet increase production and cut costs, by putting our experience, equipment and varied skills to work for you. We're equipped to handle the most complex jobs from drawing board stage to final environmental testing. New free booklet describes our facilities, shows our products, names our customers. Write for yours today.

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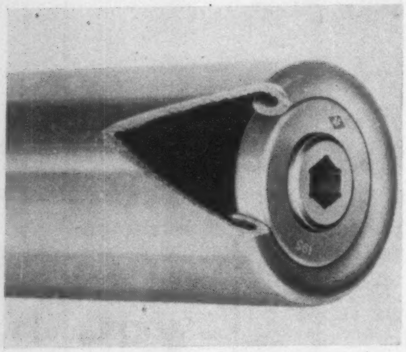
tion regarding the ratio of actual lift to maximum lift to the pilot and the automatic power control system. This allows the pilot to accomplish extreme precision control during landing approach and holding procedures. It results in greater airplane stability due to the momentum free parameters being measured.

The automatic power control system is linked to the throttles and locks an airplane to a calibrated or adjustable lift ratio during instrument approaches, both ILS and GCA holding procedures and normal approaches. It will hold a selectable speed control setting which will fully compensate for all weights and configurations during the landing approach. Autopower is an electrically independent system and is compatible with all airplanes and all automatic pilots.

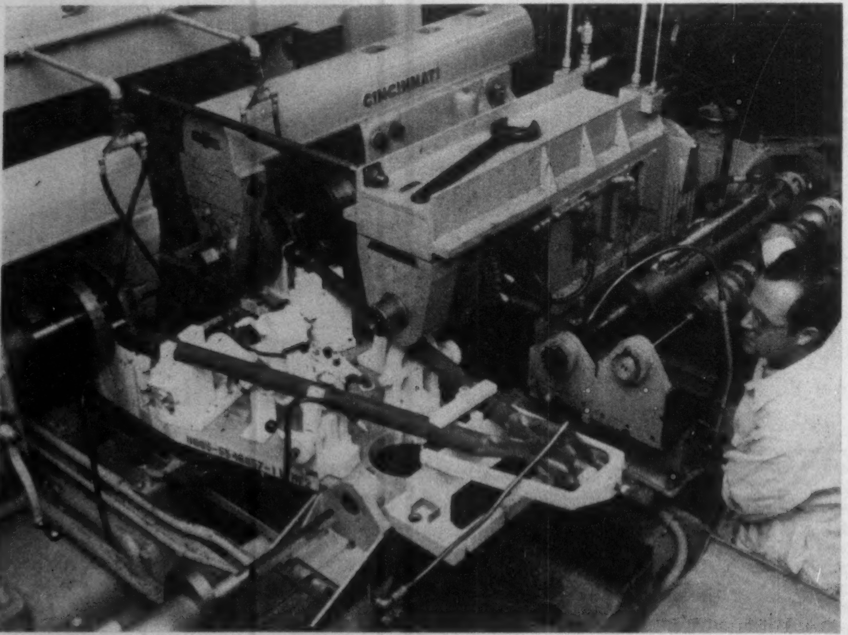


CONVEYOR ROLLER mounted on self-contained ball bearings has been developed by the Alvey-Ferguson Co., Cincinnati, O. The unit was specially designed to eliminate roller-caused damage to products, packages and cartons, as well as jamming and tie-ups with resultant downtime. The new roller houses its bearings in ends which are rolled inward to present smoothly rounded end surfaces. This rounded lip design deflects products on and off roller conveyor lines without damage by roller ends and promotes trouble free travel on the entire line.

FORMATION of a new division of Michigan Tool Co. has been announced. The Gear-O-Mation division will be concerned with the design and construction of automation equipment for high volume manufacture of gears and other small parts of similar size and contour. In making the announcement, **Marvin R. Anderson,** executive vice president, said, "A marked upsurge in demand not only for automated individual machines but for complete automation of gear lines now being ordered and an anticipated further increase in automated line orders in the future were the factors behind the formation of our new division."

**Fred T. Proper** has been named sales manager for the new division. He was formerly sales manager for the Manistee Iron Works Div. **F. Zawaski** and **Joseph Zeld** have been appointed supervisor of engineering and supervisor of manufacturing and erections, respectively.

Conveyors, transfer machines, storage and distribution systems and control systems, necessary for automated gear production will also be produced at the East Detroit plant.



STANDARD Cincinnati duplex mill has been modified by Douglas Aircraft Co. in search for most economical method of machining aircraft connecting hooks. Previously, five machine setups were necessary on variety of machines to mill two attachment fittings, straddle cut a clevis, and bore and drill three holes to precise tolerances. To the front of the standard mill, a variable speed Romulus hydraulic head has been added to straddle mill the clevis. To the front of this head are three modified Keller air feed drills which drill the required holes. Automatically sequenced operation is completed in one setup and handling from machine to machine is eliminated by the additional power units.

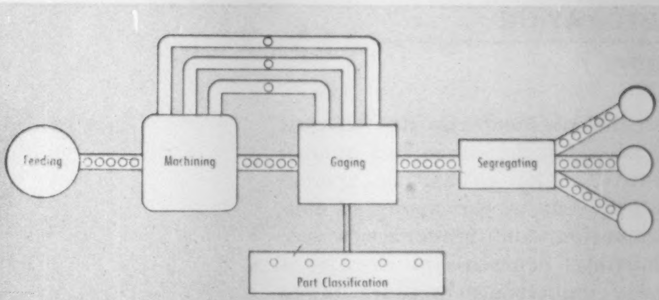
## Centralized Spray System Handles Abrasive Materials

CIRCULATING system for ceramic finishes in the Hotpoint Co.'s Chicago plant supplies identical material to three spray stations, insuring uniform finishes on all range components. In operation, after the frit has been milled, it is stored in large stainless steel tanks on a balcony above the mill. From there, it flows by gravity through magnetic separators to a pump which lifts it to two mixing tanks on another part of the balcony. Specially designed stainless steel air-driven agitators prevent the frit from settling out in these tanks.

From these mixing tanks the frit is pumped past all spray stations through a closed system of stainless steel pipes. Frit which is not sprayed returns to the tanks in the mill room for recirculation. Two diaphragm-type pumps that circulate the frit are specially designed to withstand the abrasive action of the frit. The heart of the system is a new model regulator at each spray station. This regulator developed by Binks Mfg. Co., Chicago, Ill. maintains the desired flow and fluid pressure at each spray station, regardless of its location on the pipe line.

With ceramic material being handled and mixed in a central location under laboratory conditions,

# AUTOMATION DEMANDS *RELIABLE CONTROLS*



**Dimensional control is the very heart of automation for the metalworking industry. Consequently, care in the selection of In-Process and Post-Process control devices is very important.**

**As a long recognized leader in air, electric and electronic gaging, Sheffield is prepared to furnish either:**

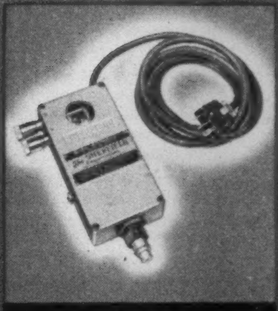
- **Packaged controls and tooling ready to install**
- **Complete automation gaging and transfer systems ready to operate**

## *FUNCTIONS and ADVANTAGES*

- Determine minute dimensional variations, rapidly and with repetitive precision
- Initiate warning signals
- Actuate control mechanisms
- Segregate acceptable, oversize and undersize parts
- Accurately classify parts by sizes
- Accommodate almost limitless range of tolerances
- Operate with interchangeable tooling
- Are small, compact and easily mounted
- Have unusually long, trouble-free service life
- Are easily interchanged

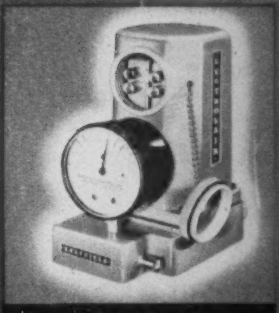
7125

**Shown here are a few of those Sheffield control units so widely used in automated systems.**



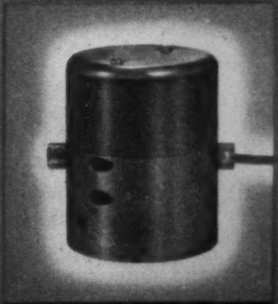
**AIRLECTRIC**

A limit type pneumatic control to actuate signals and relays.



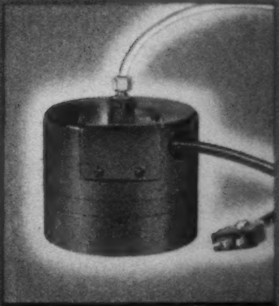
**LECTROLAIR**

A sealed-in control to actuate signals and relays and also to give visual size indication.



**DIFFERENTIAL**

A gage head for checking taper, hole parallelism or hole center distance and converting the result into an actuating electrical impulse.



**VARIATION**

A pneumatic gage head for external or internal dimensions and face to axis runout—converts the result into an actuating electrical impulse.

For more detailed information,
write for Bulletin AU-1154

The Sheffield Corporation
Division 500
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MASTER CRAFTSMAN SHEFFIELD HEADQUARTERS

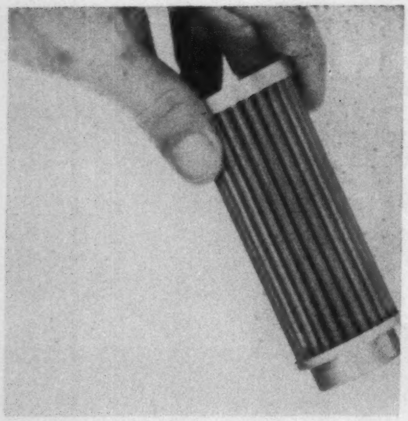
**SHEFFIELD**

MANUFACTURE AND MEASUREMENT FOR MANKIND

*Circle 565 on Inquiry Card*

substantial economies are effected in materials handling and quality control. The circulating system greatly reduces the chance of contamination, and minimizes waste. Finishing departments are freed from cumbersome pressure tanks and the network of hoses that connect them. Production is increased because the applicators spray continuously without interruption for changing of tanks.

ACCORDING to a recent announcement by Frank Groeneveld, president of Planet Corp., **Warren J. Zeis** has joined the corporation as chief engineer of the conveyor division. Zeis succeeds Robert E. Place who has been named manager of Planet's automation section.



CAPABLE of handling fluids ranging up to 1000F, a new sintered metal filter has been developed by Purolator Products Inc., Rahway, N. J. The filter can remove particles as small as one micron size from a wide range of fluids, including such materials as nitric acid, hydrochloric acid, sulphuric acid and strong alkalies. Filters of stainless steel, monel and other metals can be made as required. The development of the new filter by Purolator was accomplished with the co-operation of Horizons Inc. of Princeton, N. J., metallurgical research laboratories.

## Monitor Protects Machinery

VIBRATION monitor which anticipates and prevents trouble in rotating and reciprocating machines has been developed by the Beta Corp., Richmond, Va. The device operates by responding to slight increases in roughness or vibration and causing a shutdown before a failure occurs. Examples of detectable malfunctions are failing bearings, bent shafts, unbalance, broken blades, etc. Applications include pumps, motors, compressors, blowers, gas engines, diesels, centrifuges, turbines, generating equipment, test stands, etc. It may be used singly on small equipment; in pairs on driving and driven equipment, or in series or parallel combinations to monitor each bearing. Acceleration range is 0-2 g to cover all types of rotating equipment at speeds up to 18,000 rpm.

## MEETINGS AND EVENTS

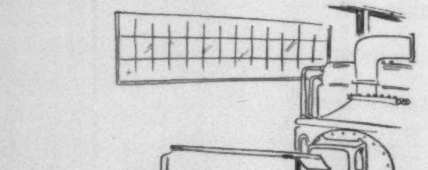
**Aug. 21-24—**
**Western Electronic Show and Conference.** Cosponsored by West Coast Electronic Manufacturers Association and Institute of Radio Engineers. To be held Los Angeles, Calif. Additional information may be obtained from Wescon, 344 N. La Brea Ave., Los Angeles 36, Calif.

**Sept. 11-12—**
**Radio - Electronics - Television Manufacturers Association.** Second conference on reliable electrical connections to be held Irvine Auditorium, University of Pennsylvania, Philadelphia. Additional information may be obtained from J. A. Caffiaux, 650 Salmon Tower, 11 W. 42nd St., New York 36, N. Y.

**Sept. 11-14—**
**Packaging Machinery & Materials Exposition.** Sponsored by Packaging Machinery Manufacturers Institute to be held Public Auditorium, Cleveland. Additional information may be obtained from the exposition headquarters, Suite 759, One Gateway Center, Pittsburgh 22, Pa.

**Sept. 17-21—**
**Instrument Society of America.** Eleventh Annual Instrument-Automation Conference and Exhibit to be held Coliseum, New York City. Additional information may be obtained from exhibition headquarters, 250 W. 57th St., New York, N. Y.

**Sept. 24-28—**
**Trade Fair of the Atomic Industry.** Sponsored by the Atomic Industrial Forum Inc. to be held Navy Pier, Chicago. Additional information may be obtained from the sponsor, 260 Madison Ave., New York 16, N. Y.



*Anybody got a hairpin?*

**Oct. 1-3—**
**Twelfth Annual National Electronics Conference and Exhibition.** To be held Hotel Sherman, Chicago. Additional information may be obtained from G. J. Argall, DeVry Technical Institute, 4141 Belmont Ave., Chicago 41, Ill.

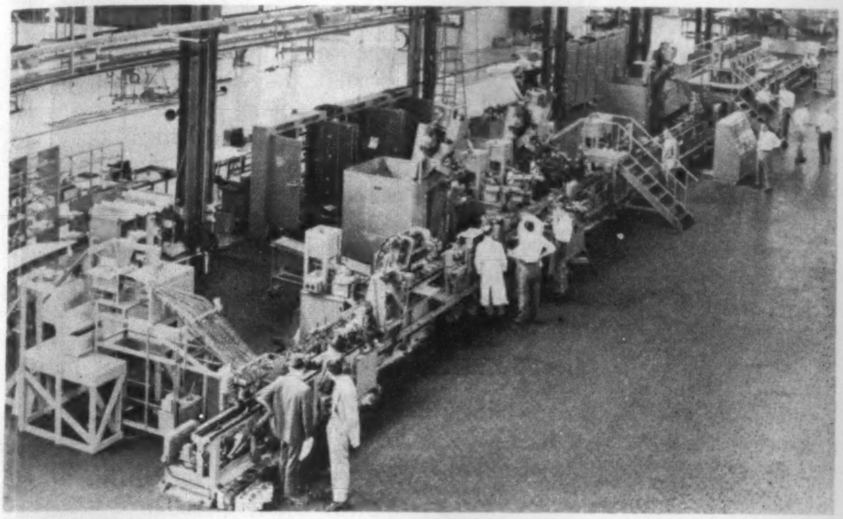
**Oct. 3-5—**
**Standards Engineers Society.** Fifth annual meeting to be held Hotel Willard, Washington, D. C. Additional information may be obtained from the society, P.O. Box 281, Camden, N. J.

**Oct. 9-10—**
**Illinois Institute of Technology.** Conference on computer applications. To be held Chicago, Ill. Additional information may be obtained from J. J. Kowal, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

**Oct. 22-24—**
**Purdue University.** First Conference on Manufacturing Automation cosponsored by AUTOMATION Magazine. Additional information may be obtained from Editor, AUTOMATION, Penton Building, Cleveland 13, Ohio.

## detroit dateline

By **JAMES C. KEEBLER**
Associate Editor



Cylinder head assembly machine developed for Oldsmobile Div. by the Process Development Section at General Motors Technical Center. The 137-foot long machine assembles 75 parts to a head, which has been placed on an indexing transfer mechanism that moves it to stations where head bolts, spark plugs, valves and related parts are assembled.

# Manufacturing Research

YESTERYEAR'S tin lizzy often suffered the indignity of being cursed at and referred to as a bucket of bolts. Today's motor car enjoys a much more respectable stature. Automotive advancements have added up to give the modern motorist a gleaming masterpiece of stylish design that is smooth to look at and to operate.

### Plow and Seed

Much of the progress can be attributed to research. Seed money, plowed back into the business with the hope of still more bountiful harvests yields a return by providing the customer with a more desirable product. Men dealing with the basic sciences are constantly snooping for new fundamental information that will help: Make better use of the fuel, master the demon friction, discover stronger-longer wearing materials, and provide the engineers with chemical, physical and mechanical discoveries that germinate only in laboratories.

Research ideas have ripened into enough fruitful realities that no one nowadays need apologize to the ownership for spending a buck now on a calculated risk that it'll get you five later. This kind of gamble is such a surefire thing that the little something the country is putting in the research pot now rings up to be $5 billion a year.

### Cultivate

Automakers' experiences with automation have shown that research aimed at the product alone is not the only type of scientific endeavor in which they should be engaged. Production process improvements hold a vast potential of manufacturing cost savings. Here is another field to be cultivated. Where new manufacturing techniques can be developed that have far reaching possibilities for future application, there is good reason to say that the cost of this type of research should not be assumed by any one specific current production item.

Outmoded systems that required each production item to pay the full cost of all equipment used in its manufacture, seriously throttled the rate of progress toward better ways to make the parts. Enlightened management that saw the wisdom of budgeting a per cent of the sales dollar for research, also saw the sense to cutting a slice of the research pie for manufacturing development.

### Big Farm

GM's acreage at 12 Mile and Mound Roads in Detroit holds the recently dedicated Technical Center wherein most of the corporation's research dollar is spent. Here Manufacturing Development takes its place among the Research, Styling, and Engineering Staffs that make up the Center. The main activity of this manufacturing staff is the Process Development Section. Facilities include chemical, physical, metallurgical, spectrographic, and electronic laboratories equipped with analog computer and testing equipment. In addition to the laboratory gear this section has a selection of production machinery that enables its staff of processing engineers to complement the work of operating division engineers in solving manufacturing problems.

Three basic objectives cited for this work are: To improve quality of the product, improve working conditions of the employees, and reduce the cost of the products.

The engineering groups that comprise this activity work on their projects without being pestered by the bugs in other current production problems upon whose solution the day to day production schedules depend.

Circumstances of this arrangement allow research to proceed along lines that a particular division alone would not have the time or money to undertake. Just as all divisions share in the cost of the seed, all can share in the harvest for this section is a clearing house for technical processing know-how.

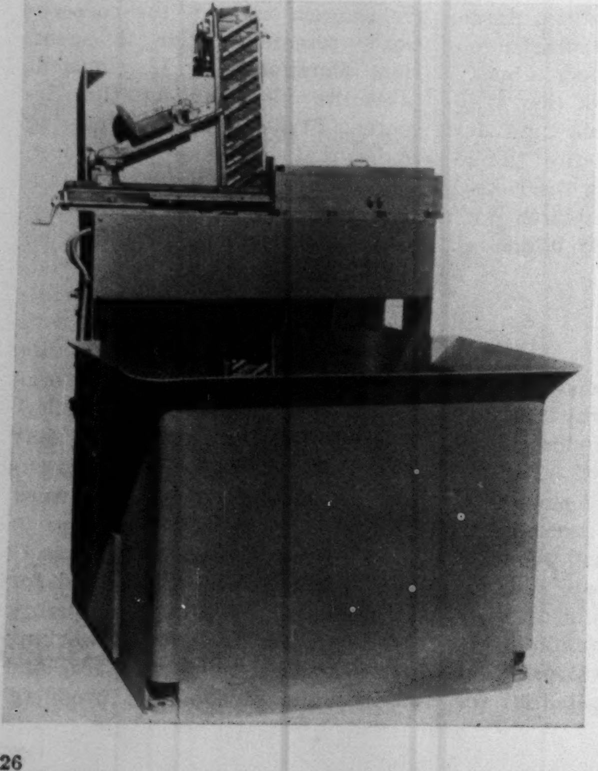
Glen Fitzgerald, director of the Process Development Section sees a trend toward closer teamwork between automotive product engineers and the processing engineers. Where design alternatives show significant production cost differences, the process becomes a deciding factor in finalizing design decisions.

### Waving Grain

You can tell which way the wind is blowing by looking at the waving grain. Research efforts aimed at determining the best method of manufacture are giving all automakers improved metal casting, cutting, forming and finishing techniques; and are devising better welding, inspecting and assembling machines.

Some other industries have had little choice but to study their processes in minute detail. Most chemical and rubber products would not turn out to specification if variations were introduced in the sequence of operations. A change of the timing and order of mixing a devil's food cake can transform the ingredients into chocolate brownies of a density and consistency much different than the product you hoped to bake. Most machined products, however, can be made to blueprint specs by any of a great number of different combinations of operations. The trick is for the process engineer to specify the best sequence for the circumstances present, considering quantities required and the machinery and tools available or devisable to do the job.

As production quantities become larger and a greater per cent of the total production costs are direct operating costs, the amount that can be saved by processing improvements increases tremendously. There's no point in trying to save a few pennies by micromotion studies of an operation that could be eliminated by a process analysis. The latter saves dollars.



Another example of the trend toward king-size hoppers is this 10 cubic foot capacity Feedall unit with 6-inch wide belt. Unit is equipped with induction heater and feeds heated parts to the production machine.

### Produce

The old bucket of bolts has given way to models that are loaded with examples of the results of understanding co-operation between those who specify what the vehicles shall look like and those who specify how to make them so that they do. You see frames of bent tubing, stamped and welded rear axle housings, open end rear fender stampings, spokeless wheels, ball joint front suspension details, and a host of others.

While some of these developments serve to eliminate assembly operations, the process engineer is automating those that remain. The assembly machine for putting 75 parts into the completed cylinder heads of the Oldsmobile Rocket engines provides an example of the technological advances made possible by cooperative effort between a GM division and the Research, Engineering, and Process Development Sections located at the Tech Center.

Observations of this development point out a trend noted elsewhere in the industry. Hopper sizes for parts feeders are getting bigger. To satisfy the appetite of an assembly machine without losing the time advantage gained by automatic feeding and orienting, the feeder must have ample storage capacity so that it won't need constant refilling.

As production rates go up the process engineer will plan for still larger hoppers. The Feedall units used to feed large bolts on the Olds head line have hopper dimensions of approximately 6 feet by 6 feet by 8 feet.

Pneumatic Scale Corp. has a machine with a king size hopper that puts caps on mayonnaise jars at the rate of 300 per minute and there is every reason to assume that the caliber of manufacturing processing being developed in the automotive industry today will require machines with the capability of performing at comparable rates.

Population and market trends have been pointed out to the nation. There's a need for the manufacturing research of today to provide the automation know-how to produce the bumper crops we'll need in the future.

Circle 568 on Inquiry Card→

AUTOMATION

AUGUST 1956

# Production or Pounds?

For many years it has been the common practice to buy and sell production equipment at fixed prices. Machinery and equipment cost could virtually be reduced to dollars per pound. Little thought was given by the buyer to the engineering time involved in developing new equipment. Builders have had to plan on offering basically standardized equipment and absorbing engineering costs over many years of sale.

With automated equipment this practice creates severe problems. In most cases machinery and equipment systems must be special. Engineering costs cannot be prorated and therefore become an important part of the total cost. In a recent talk, Mr. K. B. Hollidge, executive vice president of the Arthur Colton Co., Div. of Snyder Tool & Engineering Co., emphasized this point:

"We have found time and again from experience that the highest production machines are special design, and that the best is never achieved with standard designs. For that reason, there is a large amount of design time put in on each machine—design time that will probably never be recouped by our company since another machine like it may never be built".

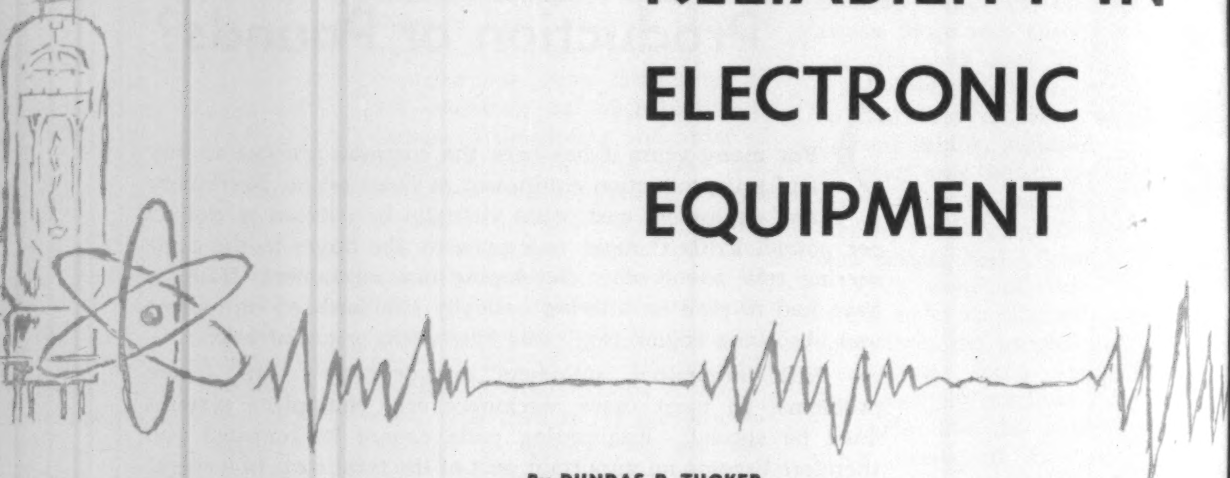
Manufacturers have been loathe to accept engineering expense as a vital component of special equipment. But to expect results with automated lines bought on the basis of price only—ignoring engineering time and, most important, proved engineering ability—is sheer folly. There is ample evidence to prove the point.

Today, engineering design of the automated system is paramount—building the equipment offers few problems. Even the basic study of the production problem for developing and proposing a practical system becomes an expensive operation. Few specialists can absorb such costs on the basis of competitive bidding and a merely passing interest by the manufacturer.

It is time for a change in approach to acquisition of production machinery where automation is involved. More careful study of product design and possible production systems is desirable along with thorough research into automation systems. A little additional investment will pay big dividends in sure-fire results.

**EDITOR**

# ATTAINING RELIABILITY IN ELECTRONIC EQUIPMENT



**By DUNDAS P. TUCKER**
Rear Admiral, USN, Retired*

HOW RELIABLE is electronic equipment and what are the factors affecting its reliability? This is a vital question to many a management executive or plant supervisor faced with the automation problem and the complex electronic equipment which so frequently goes with it. These same questions have troubled the Navy ever since it pioneered in radio communication over half a century ago. To the industrialist, electronic failures, at worst, mean costly time lost. To the naval man, they can mean loss of a ship or even a battle.

For these reasons, the Navy has waged a constant and intensive campaign to improve the reliability of its electronic equipment. Many of the lessons learned the hard way can be applied to industrial electronic designs by engineers trained in meeting military specifications. To the man with no or limited electronic background, however, military specifications are a difficult guide to apply to his own problems. Furthermore, such specifications are far from telling the whole story.

Therefore, this article is an attempt to provide an orientation in the field of electronic equipment reliability as it affects industrial automation, and to apply naval experience to some of its problems.

**The author firmly believes that electronics will become a dominant factor in automation systems of the future, but that progress has been retarded through lack of familiarity and confidence on the part of the mechanical pioneers in automation. His article is designed to orient management and the technical executive who are interested in evaluating the reliability of electronic systems for automation applications.**

## ▸ Reliability at Its Worst

Let us consider some extremes in electronic reliability. On the low side is the experience of the Navy several years after World War II. During that period, over half of its electronic equipment was either inoperative or operating much below par. There were two basic reasons for this intolerable situation—inadequate design and inadequate maintenance. Most of the equipment then in use was hurriedly designed during the war by engineers relatively unfamiliar with the exacting requirements of military operation and also unfamiliar with the then very immature and new electronic techniques which poured out of the research laboratories under the spur of war necessity.

There was little time to work out the inevitable bugs. The writer well remembers certain frantically developed and vital gun control radar which was rushed into production from a laboratory model in 1941. As a result of this haste, over 300 field modifications were made on this equipment during the

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* Formerly director, Navy Electronics Laboratory.

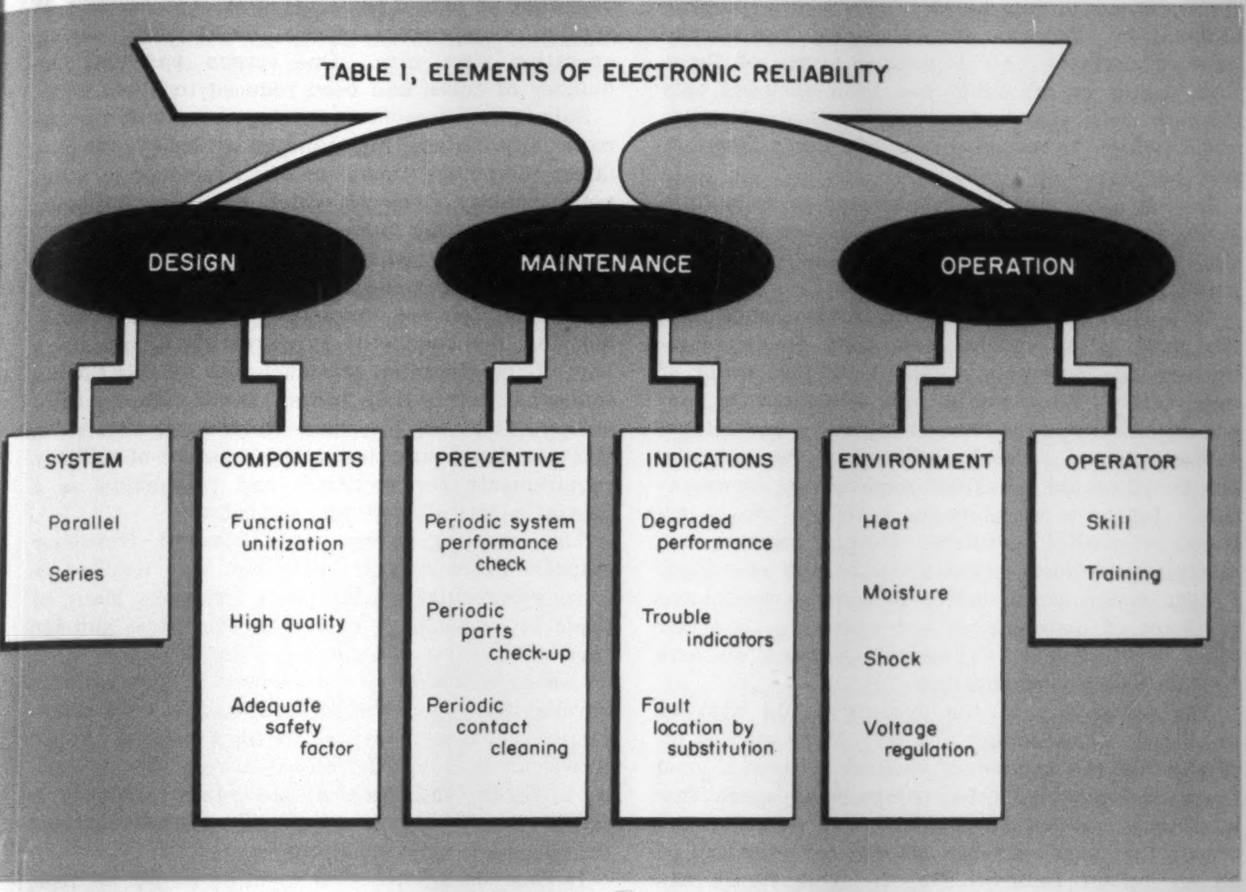


TABLE 1, ELEMENTS OF ELECTRONIC RELIABILITY
DESIGN
MAINTENANCE
OPERATION
SYSTEM
Parallel
Series
COMPONENTS
Functional unitization
High quality
Adequate safety factor
PREVENTIVE
Periodic system performance check
Periodic parts check-up
Periodic contact cleaning
INDICATIONS
Degraded performance
Trouble indicators
Fault location by substitution
ENVIRONMENT
Heat
Moisture
Shock
Voltage regulation
OPERATOR
Skill
Training

war in order to improve its performance and reliability, in spite of the fact that it was engineered by the leading and most reliability-conscious electronic firm in the country. Finally, it was replaced in 1944 by a new model with much better performance and reliability, based on the lessons learned in combat on the 1941 model.

No apologies are necessary for such an uneconomic performance. Under the circumstances prevailing, comparatively inefficient and unreliable radar was far better than none at all. Actually, it accounted for many more enemy casualties and successful battles than the newer and better engineered model which arrived when the war was nearly won.

User reaction to this situation, by the way, is also interesting. Complaints of unreliability from the fleet were loud and frequent. Some of this was due to unfamiliarity with a new type of equipment. By the time the new and improved model reached the same users, they had also greatly improved their maintenance know-how and complaints on the new radar became rare.

This situation has significance for the industrialist who is faced with sudden and serious competition from a new development. If he waits until all the bugs are worked out of the new system before buying it, he will save money in the beginning but lose some valuable experience which may later prove costly to his future competitive position. The man who keeps himself in the forefront of technological progress does so at the price of present headaches but at a saving of headaches in the future.

This then is the reliability picture at its worst, where most of the circumstances are adverse. It has provided a grim lesson to the Navy in its recent and much more successful effort to improve the reliability of its latest electronic gear. The necessity for a much greater order of reliability is also demanded by its burgeoning guided missile program. Expensive guided missiles have to work right the first time, because there is no second chance to make adjustments after firing. Success in future wars that might occur will depend more heavily on weapon reliability than at any time in the past. This requirement has resulted in an unparalleled joint effort between the military user and the industrial manufacturer to improve the reliability of electronics.

## ▶ Elements of Reliability

Where conditions are favorable, industry has proved that a very high degree of electronic reliability can be attained and maintained over the years. The long distance telephone system is an outstanding example. In spite of its almost unimaginable complexity, which is increasing at a frightening rate, the reliability of the telephone system seems to improve as it approaches complete automation. Outages are so quickly located and handled that the user is seldom aware of them. This degree of reliability has been achieved only through long years of research, standardization, and devotion to an ideal of perfection. There is no other way.

Let us now examine the elements of reliability. When these are understood, we are then in a position to evaluate the probable reliability of electronic equipment or systems.

Overall reliability of an electronic installation, like most other systems, rests upon design, maintenance and operation, TABLE 1, in that order of importance. These can be compartmented for convenience in discussion, but are actually interrelated to some degree. Design deficiencies, for instance, can be alleviated by skilled maintenance or operation. Likewise, maintenance problems can be reduced by careful operation. Design, however, has much more effect on maintenance and operation. Proper design can probably do more to reduce the problems of maintenance and operation than any other single factor. Therefore, suppose we look first at design considerations.

The philosophy of the system should first be examined. How complex is it? Navy studies indicate that the number of vacuum tubes is a good index of complexity, other things being equal. This is directly related to reliability, if only for the reason that vacuum tubes account for over half of all equipment failures, *Fig.* 1. This figure has risen as high as 85 per cent in some instances. One of the earliest electronic computers ten years ago had 18,000 tubes and an outage time approaching 90 per cent. A modern design of comparable performance recently seen by the writer had a downtime of only 5 per cent, most of it due to preventive maintenance work. Breakdowns during operation were rare. One reason was that the number of tubes had been reduced to about 3000.

Subsequent computer developments will further materially reduce the number of tubes. In the latest computers, tubes are often replaced by magnetic memory elements which have extraordinary reliability. Other tubes may be replaced by magnetic amplifiers where relatively slow speeds of operation are permissible. The magnetic elements of an amplifier are characteristically very reliable, but the semiconductor type rectifiers, usually a part of the amplifier, are much less reliable though somewhat better than tubes. Semiconductor technology, however, has made impressive strides in the past few years, due to the pressure of military requirements for rectifiers and transistors as a partial substitute for vacuum tubes.

The usual growing pains plagued transistor manufacturers several years ago and resulted in some spectacular performance failures. Many of these problems have now been overcome, and the tiny, efficient transistor is beginning to live up to its advance billing as the answer to vacuum tube unreliability. Nevertheless, the vacuum tube manufacturer is now beginning to fight back in typical American style by radically improving his product. As a result, the cause of electronic reliability is being greatly advanced by this competition, and the outlook is most encouraging.

In this connection, some mention should be made of the so-called reliable vacuum tube which has appeared on the commercial market during the past several years. These were the outgrowth of a project pioneered by the Navy for the purpose of improving existing tube types. In practice, they

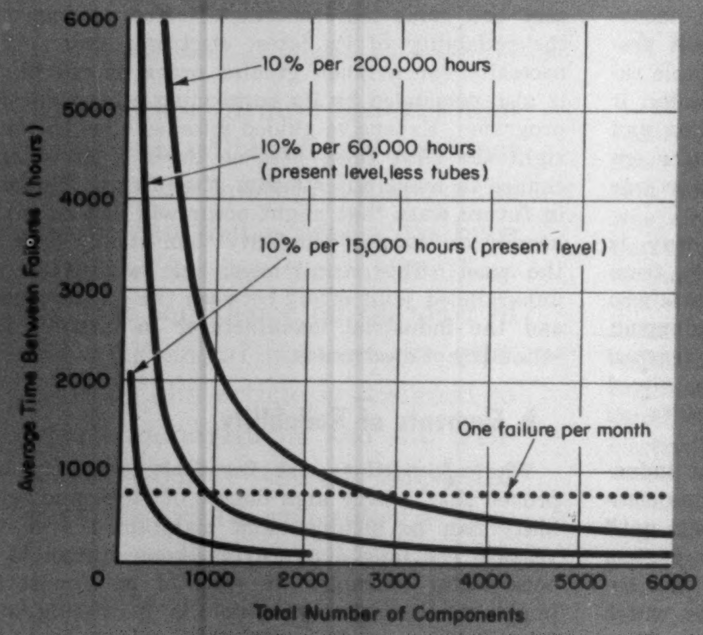


Fig. 1—Effect of complexity on reliability at three typical part-failure levels. This shows how rapidly the time between failures decreases as the number of parts approaches 1000. Levels are only illustrative and are not necessarily applicable to a particular system.

*Official U.S. Navy Chart*

have amply justified their higher price by averaging about four times the life of the ordinary tube, and saving the time of valuable maintenance men.

## Complexity and Reliability

Having taken this opportunity to highlight the leading role which the vacuum tube plays in the reliability picture, let us now return to the subject of complexity. Complex systems can sometimes be classified as parallel or as series systems. Of the two, the parallel type is the more reliable. The automatic telephone is an example of a parallel system in that it has a number of independent channels. In this system, the failure of a single channel seldom affects the operation of other channels, and the system as a whole usually continues to operate unimpaired. A series system, on the other hand, is like a chain. When one link fails, the whole chain fails.

*Official U.S. Navy Photo*

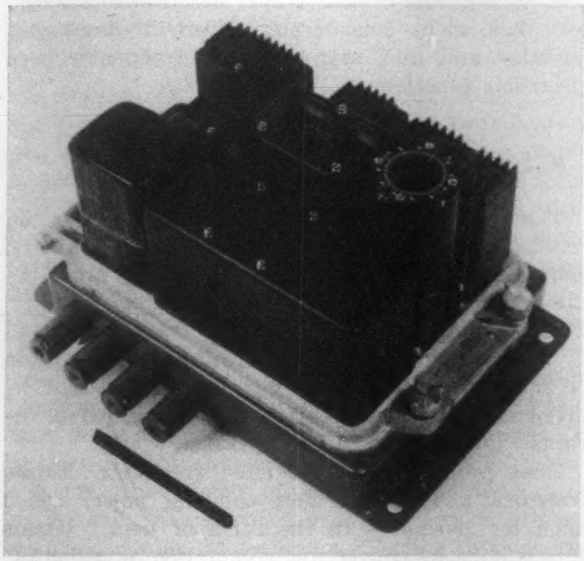


**Fig. 2—Functional unit developed at the Navy Electronics Laboratory—a combined junction box, wired chassis, and set of plug-in units comprising complete equipment.**

Unfortunately, too many of our complex electronics systems are of the series type. When we look into the mathematical probabilities of failure in a series system, where the failure of any one of its numerous critical parts can cause system failure, we get a discouraging picture. For example, the probable reliability of a simple piece of equipment with thirty critical components, each with a probable reliability of 99 per cent, is only 74 per cent ($0.99^{30} = 0.74$). Likewise a large complex system of one thousand critical parts such as a computer, each with a greater reliability of 99.99 per cent (high figure for most vacuum tubes), would also have an overall system reliability not appreciably improved.

In a large complex system of the series type, improving the individual components soon runs into the law of diminishing returns. The designer must then devise means for living with a considerably less-than-ideal reliability figure. He does this by reducing the outage time as much as possible, once a failure has occurred. He incorporates test devices or indicators which allow the maintenance man to locate the source of failure with a minimum of delay. This is far more important in electronic equipment than in mechanical equipment, because a failed electronic component is seldom distinguishable from a good one by visual inspection. Often it has to be located by observing its behavior on special test equipment, a time consuming process where many components are involved.

One old shipyard repair supervisor bemoans the advent of electronics in this fashion: "In the old days when a ship used to come in for overhaul, I could walk through the whole plant with the chief engineer and often see what was wrong at a glance. The chief would say, for instance, pointing out a leaking pump, 'That pump needs repacking.' I would say 'Damned if it don't' and I could estimate within an hour how long it would take to fix it. Now he says to me, 'That radar set doesn't work,' and I know it may take the repairman anywhere from an hour to a week to find out why, and what has to be done."

## Unitized Design

More and more designers are turning to functional unitization as one solution to the problem of rapid fault-location, and also to the problem of rapid restoration of service once the defective unit is located. This now widespread concept of rapidly replaceable functional units is one of the greatest recent steps in the advancement of electronic reliability, *Figs.* 2, 3 and 4. It also offers some other important advantages in production and in maintenance operations.

Let us first explain what we mean by functional unitization. For instance, the average modern high-fidelity home music installation uses functional unitization on a small scale. This is seldom the result of any special attempt to improve reliability, but rather due to the need of flexibility. Nevertheless, it does provide a familiar example of unitization. A typical installation consists of separate functional units: Record player, radio tuner, pre-amplifier, power amplifier, and loudspeaker. If one of the units fails, a few simple tests usually locate the nonfunctioning unit, which can then be swiftly unplugged and taken to the dealer for repairs. If the owner wishes to maintain his music system in operation during the repair period, he can borrow an indentical unit from the dealer.

Although the hi-fi example is a very elementary one, it contains most of the basic elements and philosophy of functional unitization: (1) Separately packaged chassis which performs a single, easily recognized function; (2) ease of locating a defective unit by a moderately skilled operator; (3) ease and rapidity of replacement by the operator with an identical standard unit from stock; (4) repair of the defective unit by a skilled specialist in a properly equipped repair shop, rather than by time-consuming and sometimes awkward repairs in the operating area; (5) maintenance of operations during repairs.

This unitization concept of complex systems is particularly advantageous in electronic computers. Here there are several types of units, each of which are repeated in numerous identical units. One large computer uses as many as forty identical plug-in memory units, any one of which can be pulled out and replaced with a spare by manipulating a simple latch. All electrical connections are properly re-established automatically by means of built-in separable connectors. Such connectors, while essential to speed, can be an aggravating source of trouble from dirty contacts and misaligned prongs unless well engineered and maintained. Dusty or moisture laden air is deadly to contact reliability, and much equipment with a large number of contacts is kept in air-conditioned spaces with quite satisfactory results.

*Official U.S. Navy Photo*

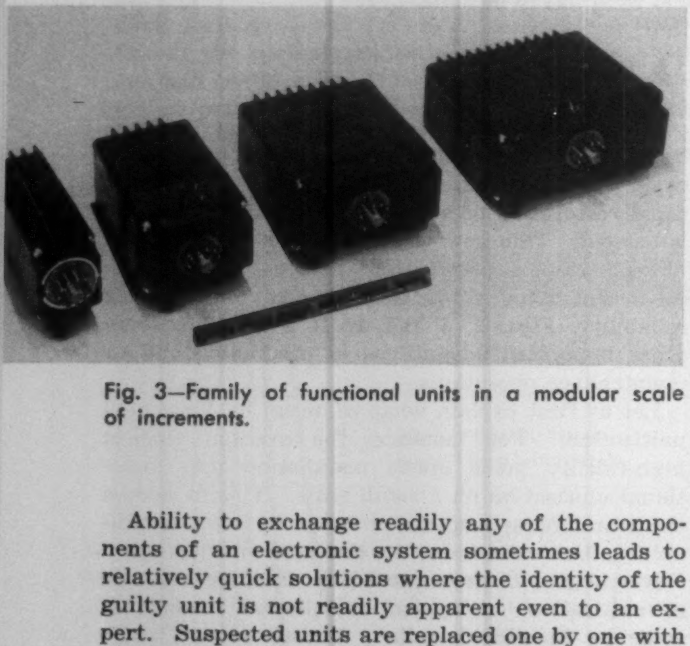


Fig. 3—Family of functional units in a modular scale of increments.

Ability to exchange readily any of the components of an electronic system sometimes leads to relatively quick solutions where the identity of the guilty unit is not readily apparent even to an expert. Suspected units are replaced one by one with an appropriate spare of known excellence, until the defective unit is located by the fact that its replacement restores the system to proper operation. This is analogous to locating the burnt-out bulb in a series-string of Christmas tree lights by substituting a good bulb for each installed bulb until the string lights up.

The unitization principle has a number of economic advantages, even though the plug-in provisions increase the size, the labor, and the material costs compared with the production costs of a conventional integrated system or equipment. With quantity production, assembly line and inspection procedures are facilitated by breaking the system into small, readily manageable units. Unitized components also lend themselves much more readily to automated processes, such as printed circuitry and dip soldering, *Fig.* 5. Finally, they save the time of the scarce and highly paid technicians since in large installations the work can be brought to them by operators or helpers. The big economic advantage which usually outweighs all extra cost, including that of stocking spare units, is the reduction in outage time.

Reduction in outage time and the scarcity of trained technicians is also the reason that functional unitization is now used to such a great extent by the Navy. The Naval Electronics Laboratory has spent considerable effort in developing modular and unit standards for frequently used electronic functions.

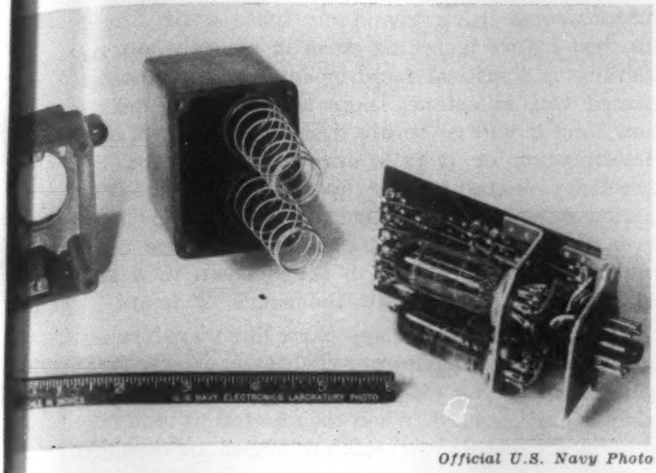
## Environment Factors

The importance of environmental factors on reliability is very great. Excessive heat, moisture, and mechanical abuse, in that order of rank, are the principal contributors to electronic unreliability. These factors are usually much more aggravated by the conditions of naval operations than by those of industrial operations, but they must still be given considerable attention by the industrial designer, installer, and plant operator.

Heat problems are the most frequent. Tubes, resistors, and transformers consume power which must be dissipated in the form of heat. Unless this is done by convection, conduction or radiation, hot parts soon develop in the equipment which eventually cause failures of these and adjacent components.

A responsible and experienced designer can adequately cope with this problem if not squeezed too hard by space, ventilation, or cost limitations. It is difficult, however, for him to guard against the occasional user who carelessly installs his equipment in a hot or poorly ventilated location. People who put their radio and TV sets next to hot radiators, or crowd them into unventilated cabinets, only contribute to the repairman's income tax. General Navy specifications require electronic apparatus to function properly in an ambient temperature as high as 122 or 149 degress Fahrenheit, depending upon circumstances.

Moisture is a serious hazard to electronic circuits, most of which operate at several hundred volts. Even a leakage of a hundredth of an ampere can sometimes cause failure. Where moisture-laden air is the problem, keeping the equipment "warmed up" at all times prevents moisture from condensing on insulating materials and greatly improves reliability, if not economy. This practice proved a real lifesaver to many a naval ship in wartime faced with the problem of keeping its equipment ready for immediate operation. It also



*Official U.S. Navy Photo*

Fig. 4—Disassembled view of weather-tight plug-in unit showing typical construction.

has another advantage that when the tube heaters are kept *on* continuously, the tubes last much longer because they are not subjected to the thermal shock of being turned *On* and *Off*. On the other hand, where water may splash, watertight enclosures must be used, greatly complicating the ventilation and heat dissipation problem.

Mechanical abuse is not usually much of a problem in the average industrial installation, except a mobile or portable one. It is an ever-present problem in many military applications and has been the subject of much test and study over the years. Except for very extreme cases of shock and vibration, most of the problems have been solved and are embodied in military specifications for the guidance of designers. During the war, the Navy solved the problem of installing vacuum tubes which would withstand the terrific acceleration of being fired from a high-velocity gun.

In electronic equipment, as in many other types of devices, much trouble results from the designer operating the components too close to their maximum load and not allowing enough margin of safety. This is often done for competitive reasons to cut costs, but is decidedly a penny wise and pound foolish policy for the user. A few cents saved by incorporating a lesser component may cost many dollars later in outage and repair time. As a general rule, most prudent designers allow at least a 100% margin of safety in rating electric components — that is to say, they operate them at half the rated load. This margin also helps guard against the overloads which sometimes occur in associated components of a circuit, caused by the initial failure of a particular part or component.

Without doubt we can safely say that when the experienced design engineer is familiar with all the industrial requirements of performance, environment, and operation, he is perfectly capable of turning out an electronic system which compares favorably in reliability with mechanical or hydraulic systems of comparable complexity. If, on the other hand, we force the designer toward the poorly charted frontiers of the electronic art, where guides to reliability based on operational experience are scarce, the early designs usually contain bugs which take about five years of use, and often a second design, to eliminate. The ultimate in simplicity and reliability in performing a desired operation can come only after design and maintenance experience is gained from several years of use. For example, the early TV sets contained about thirty tubes, whereas many modern sets of comparable performance, require less than twenty tubes. The industrial customer will find it cheapest to deal with the manufacturer with the best reputation for quality and follow-up service.

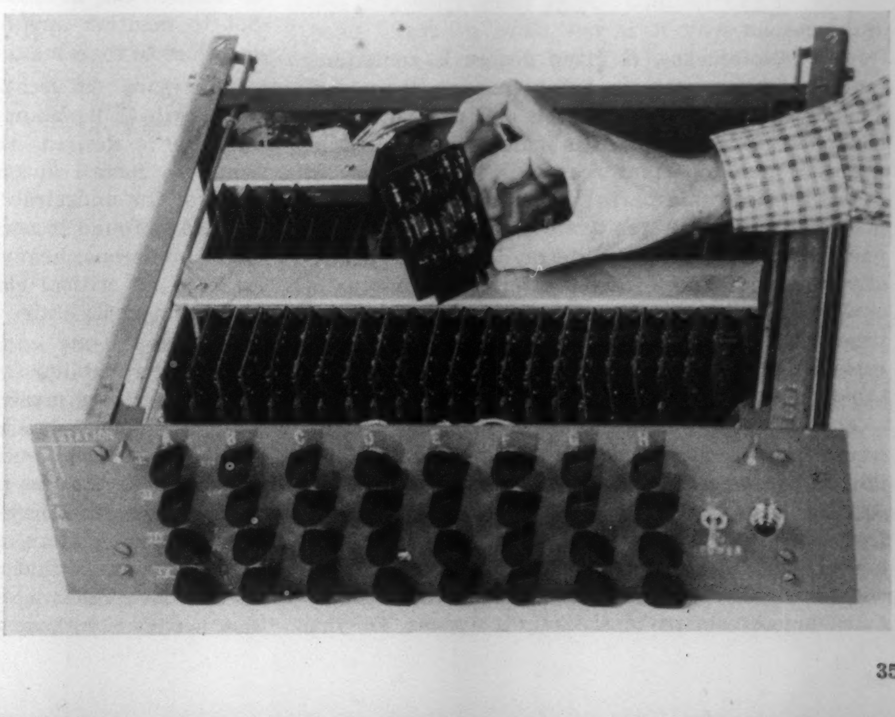


Fig. 5—Another functionally unitized equipment constructed by the Navy Electronics Laboratory consists of numerous small plug-in panels of similar design.

*Official U.S. Navy Photo*

## THE AUTHOR

**ADMIRAL TUCKER spent seven years at sea in a wide variety of jobs, after graduation from the Naval Academy in 1925. Following this sea duty he received a Master of Science degree in electronics from Harvard. He spent the next five years as Fleet Communication Officer and in charge of electronics research in the Bureau of Ships. During that period he supervised the first radar tests ever made in the fleet and participated in the design of radio equipment used in the Navy during World War II.**

**During this war he was program director of electronics, guided missiles, and nuclear matters in the Bureau of Ordnance. He established the military requirements and design characteristics of most of the fire-control radar in use at the present time. In addition, Admiral Tucker originated and combat-tested the BAT, the Navy's first service guided missile.**

**After the war, he spent three years with the Office of Naval Research, co-ordinating the Navy's research facilities, as well as originating and organizing the Research Reserve. His two previous tours of duty were Commanding Officer of the Navy Electronics Laboratory at San Diego, and Commanding Officer of the Chicago Branch Office of the Office of Naval Research. When retired, he was Commanding Officer of the Pasadena Branch Office of ONR.**

## ▶ Electronic Maintenance

So far, little has been said about preventive maintenance. It is not as widely used in electronic as in mechanical and hydraulic installations, although it certainly has an important bearing on the reduction of unscheduled outage time. There are several reasons why it is not more generally used. One is obsolescence. A given design is sometimes replaced by a newer one before enough experience has accumulated on the older one to provide an adequate guide to a realistic maintenance schedule. Another and important reason is the tendency of so many electronic parts to fail suddenly and unpredictably. Only a relatively small percentage of parts have a predictable life or deteriorate gradually at a measurable rate. Batteries are a type of equipment whose condition can be checked at any time with simple test equipment, and they can be replaced when they fall below some standard established for a particular application.

The average vacuum tube has one peculiarity worth mentioning in connection with reliability; its life can be predicted only on a statistical basis. Any individual tube may have an actual life of from several hours to a great many thousand hours. The highest percentage of failures occurs within the first fifty hours of life, when manufacturing defects are most likely to appear. For this reason, some users give their tubes a fifty hour life test before installing them in places where reliability is a critical requirement. Once a tube has passed this milestone, there is no way of telling how long it will go before it shows any significant deterioration or it fails abruptly. Therefore, the practice of installing new tubes after some specified period of use is ineffective, uneconomic, and may even reduce reliability by discarding some tubes which have only begun to settle down to a long and faithful existence of thousands of hours.

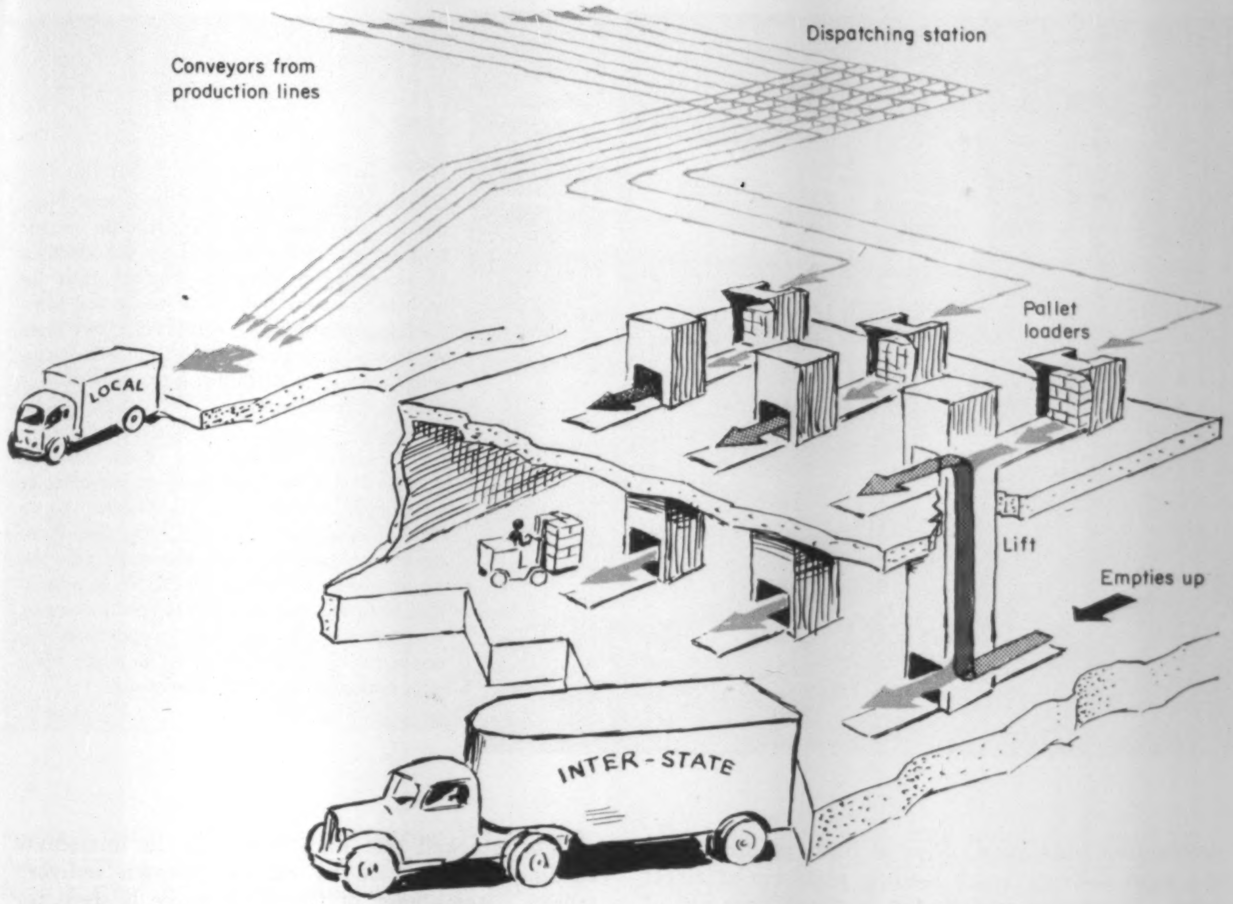
On the other hand, many parts like transformers, low-loss fixed capacitors, and conservatively rated resistors have an almost indefinite life as long as they are not abused. When they do fail, it is usually a sudden event due to moisture, shock, or overload. Therefore, no preventive maintenance schedule of replacement is of any value on them.

There is one particular area, however, where preventive maintenance is especially effective: periodic cleaning of contacts. This applies to connectors, tube sockets, switches, and relays. A large percentage of circuit failures stems from dirty contacts, and can be radically reduced by a proper cleaning schedule. Sometimes this can be a simple procedure of sliding seldom-used contacts against each other to remove accumulated dust and oxidation.

In the operation of electronic equipment, probably one of the greatest enemies of reliability is a fluctuating or a wrong power supply voltage. This is all too common in industrial areas where uneven demands on the electric power lines cause low or high voltages. Low voltage on electronic gear not especially designed to cope with it often causes erratic operation. Higher-than-rated voltages can materially shorten the life of certain parts, particularly vacuum tubes. It is especially important that the cathode heater of a vacuum tube operate within about five percent of its rated voltage, especially on the high side. Radical increases in voltage can be immediately disastrous to tubes, not to mention any other parts normally operating close to their maximum ratings.

Therefore, in locations where fluctuating line voltages are common, and where the highest reliability is desired, the user will find it worthwhile to install automatic voltage regulators. In spite of the undesirable increase in weight loading, the Navy found it necessary during the war to install numerous heavy voltage regulating devices to keep its critical electronic equipment in proper operation on its ships.

Therefore, one can say that the elements of electronic reliability for most industrial applications are neither very mysterious nor unattainable. However, the knowledge is not as widespread as it is in the older techniques and may not be as readily accessible to the less initiated. It is hoped that this brief orientation may help to alleviate that situation for the readers of AUTOMATION. It should be noted, however, that the views expressed in this discussion reflect only those of the writer, and are not necessarily those of the Navy Department.



1 Schematic representation of handling system used by C. Schmidt & Sons, Inc. to prepare shipments of beer to meet varying customer requirements. Seven product lines terminate at the dispatching station where any incoming line can be routed to any of eight outgoing lines. Mixed lot orders of 100 to 250 cases for smaller local distributors go direct to truck on one of five conveyors. Unitized loads for large trailer shipments are palletized on automatic pallet loaders and delivered to first floor warehouse on lifts that also handle return flow of empty bottle pallet loads.

AUTOMATION TODAY

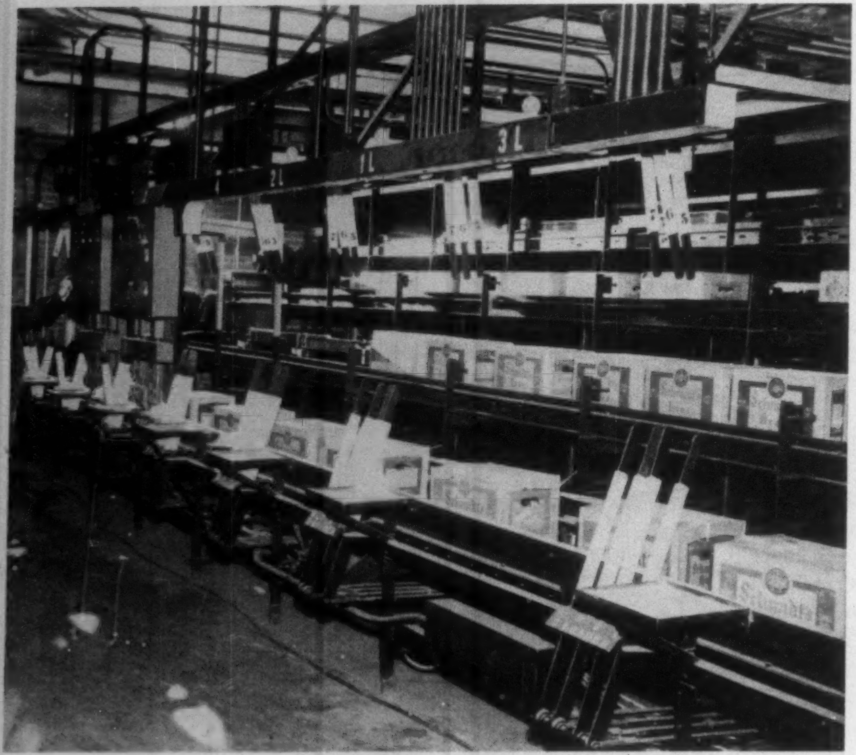
# HANDLING SHIPMENTS

MATERIALS HANDLING systems have become refined to the point where they go beyond the scope of mere transportation. Such systems can move and sort goods within a time cycle which adds to the time and place utility of the product. In so doing, these systems perform as production tools.

The system used by C. Schmidt & Sons, Inc. to handle cases of beer provides a cushion between an irregular shipping schedule and a more uniform rate of production. In this arrangement manual handling has been almost eliminated, but this could be resorted to if production and shipping get too far out of balance.

This equipment, which was engineered and installed by Lamson Corp. provides for the total output of seven bottling lines to be moved to a second floor area where filled cases are warehoused on conveyor lines. Should these live storage lines become full, additional stock is stacked alongside the conveyors or hand palletized on a mezzanine floor.

Through a system of metering belts and retractable deflectors the dispatcher can route cases from any of these seven product lines to any of eight



**2**

Orders are received on intercom from the loading platform. Dispatcher is setting up an order by dialing the number of cases of a specific product that he wishes to count out. The deflector handles (connecting the required input lines with the desired destination lines) are pulled and the metering belts will deliver the specified number of cases, automatically counted by photoelectric control. Upon delivery of the required count the deflectors are automatically retracted. Incoming conveyors serve double duty as storage for the local deliveries and as accumulators for the pallet loaders. When set for tie-in operation with the pallet loaders, an automatic scanner counts out and dispatches the cases to fill a pallet when enough have accumulated on the conveyor.

destination conveyors. Five of these go directly to the local delivery truck loading platform at street level. Conveyors and chutes in these lines are of sufficient length to provide storage of 100 cases ahead of each truck. Three conveyor lines cross the street on a bridge to the second floor of a warehouse building where each terminates at an automatic pallet loader. The remaining area of this floor is used to store pallet loads of empty bottles.

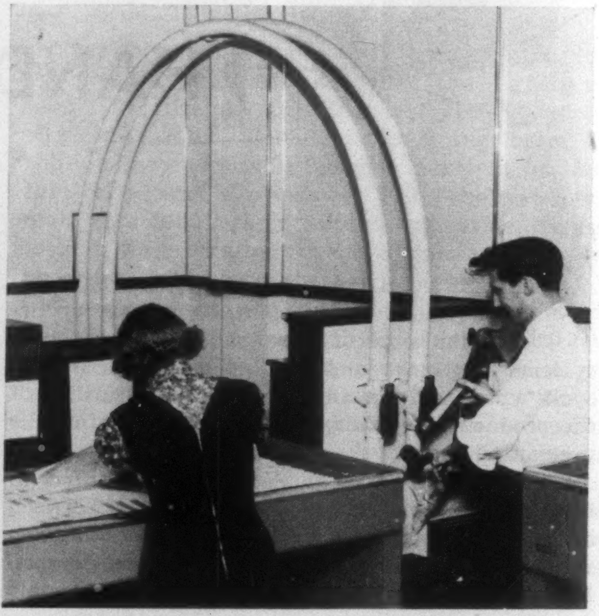
Each pallet loader has a companion reciprocating vertical lift that delivers pallets of full cases to the first floor and brings pallets of empty bottles up on its return trip. Fork lift trucks operating on this second floor are assigned to remove the pallets of empties from the conveyor at the outlet of the lift and stack them along the walls in storage or place them at the conveyors that lead to the bottle house.

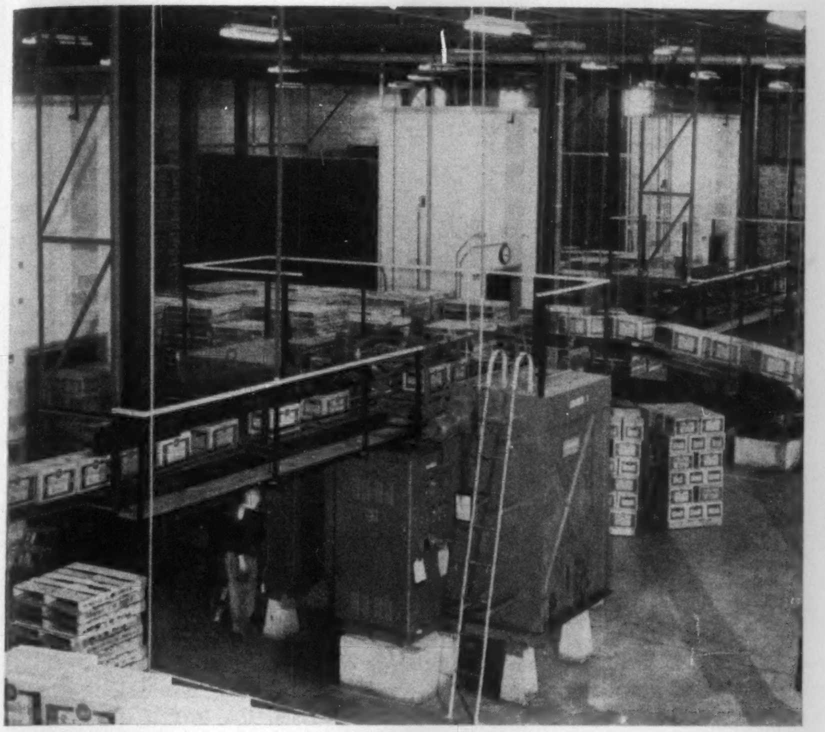
Adjacent to each lift on the first floor is an area designated for truck loading stock. Here 42 pallets, stacked one high, are kept in immediate readiness to be loaded on out-of-town delivery trucks. Remainder of the floor space is used for three-high stacking of full case pallets in storage. Lift truck operations on this floor require the removal of full pallets from the pallet lift, the transportation of pallet loads from the stock areas to the trucks, and the delivery of pallet loads of empties to the entrance of the lift.

Automatic features of the principle stations of this system are explained in greater detail with the

**3**

Incoming orders are processed into invoices before the dispatcher gets his orders from the loading platform. Billing office keeps business machine cards on each of its accounts. Cards are prepunched with information on customer's name, standard quantities and prices of each product, sales territory, and other relevant information. Purchase orders are received from the loading platform by Airtube. Cards representing each item on the order are pulled from the customer file and run through an accounting machine that automatically prepares the invoice which is sent to the loading platform by return tube.





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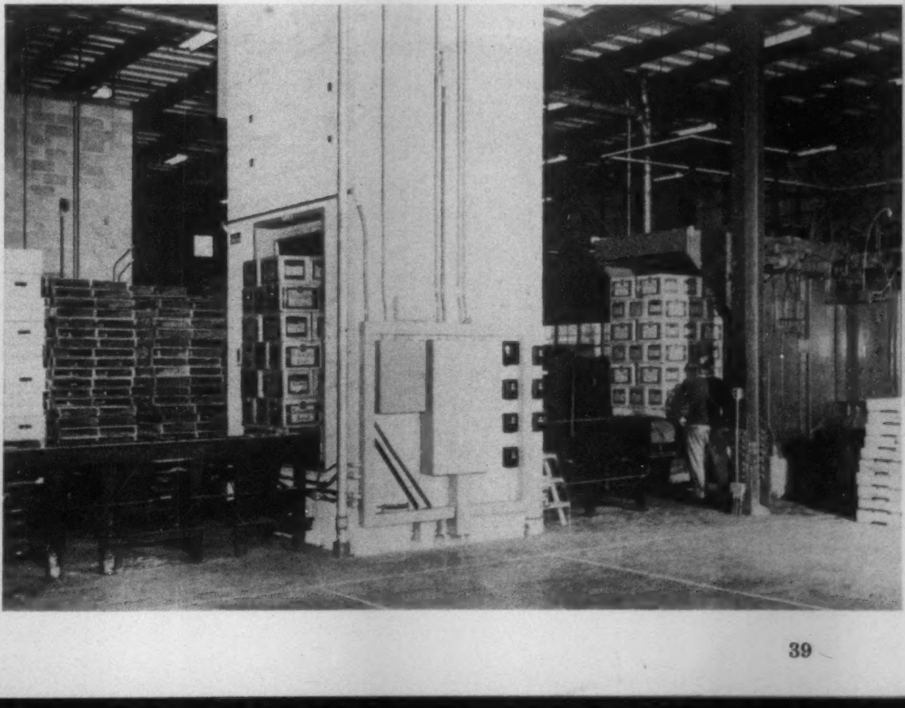
Three pallet loaders located on second floor of warehouse building are attended by operator who corrects any difficulties such as a jam that might occur if the flap of a case should become open. Machines are under the control of the dispatcher, *Fig.* 2, who selects one of three stacking patterns, depending on the size of cases to be stacked. Dispatcher's remote panel controls an electronic cartridge which programs the loader through the sequence of motions necessary to achieve the required stacking arrangement.

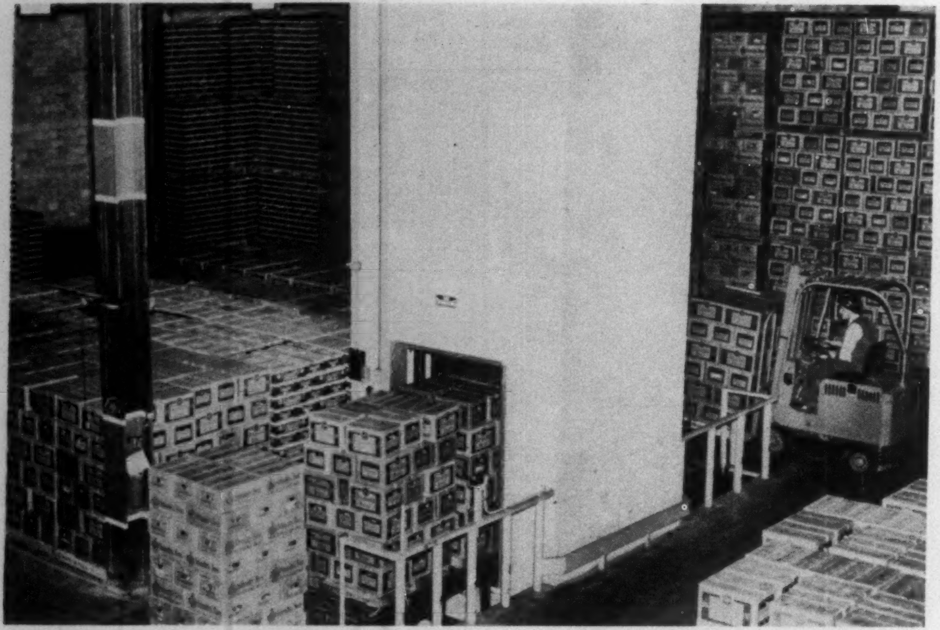
accompanying illustrations. Controls permit the dispatcher to load local trucks on the day shift from current production, eliminating the handling of that volume of product into and out of storage. If production is running ahead of shipments the surplus can be routed to the pallet loaders and stored. On the night shift the control board can be set up to tie in all production lines with the pallet loaders. The overall system is currently handling 50,000 to 60,000 cartons a day, of which about 65 per cent are palletized.

To keep pace with this automated materials handling system the Schmidt organization has developed a high-speed billing system. To satisfy legal requirements that intra-state sales be on a cash and carry basis, every local shipment involves producing an invoice before the truck can be loaded. Purchase orders are picked up from the arriving driver at the loading platform and are sent to the billing office through a Lamson Airtube line. A clerk selects a combination of prepunched cards that represent the order. These

5

Loader automatically stacks cases onto a 35 by 40-inch pallet at rates of 25 to 30 cases per minute. A two-way lift is located in front of each pallet loader. This photo shows a pallet load of empty bottles which has just come up from the first floor emerging from the lift. A load of full cases is leaving the pallet loader onto a ten-foot section of powered roll conveyor. Since the lift is in receiving position the loaded pallet continues onto the car, the doors close and the load descends to the first floor.





**6** Fork lift truck removes pallet load from the conveyor at the base of the lift. A series of electromechanical interlocks coordinates the operation of each pallet loader and lift. Each length of powered conveyor leading to and from the lifts is designed to accommodate a row of three pallets. If the discharge conveyor on the first floor is filled the lift will not bring down another pallet but the loader will continue to operate until the connecting conveyor on the second floor is also filled. When this condition exists the pallet loader automatically shuts down.

cards are run through a machine that produces a typed invoice, listing the total of each item ordered showing the extended and totaled costs. Credits are shown for the empty bottles returned. Completed invoices are sent to the shipping platform via Airtube. This system helps materially in maintaining a high rate of turnover at the loading platforms.

Running totals of daily shipments are supplied by the accounting machine that prepares the invoices. These totals are used to schedule brewery production. This comprehensive system serves as an example of what can be done to co-ordinate the interrelated factors of continuous production rate, quantity of inventory, available warehouse space, immediate delivery needs, and paperwork requirements to provide efficient servicing of shipments to customers.

**7** Line of trailer loading berths is shown at right. Operator at left is placing a pallet load of empty bottles on the conveyor that feeds the *Up* trips of the lift. The discharge side of the system on the second floor has its quota of three pallets of empties. When this line is full the lift will not accept another pallet from the first floor and the conveyor there will accumulate three pallets. Both *Up* and *Down* systems function such that as a pallet is removed from a full conveyor, the remaining pallets advance one position and the operations feeding that conveyor resume automatically.

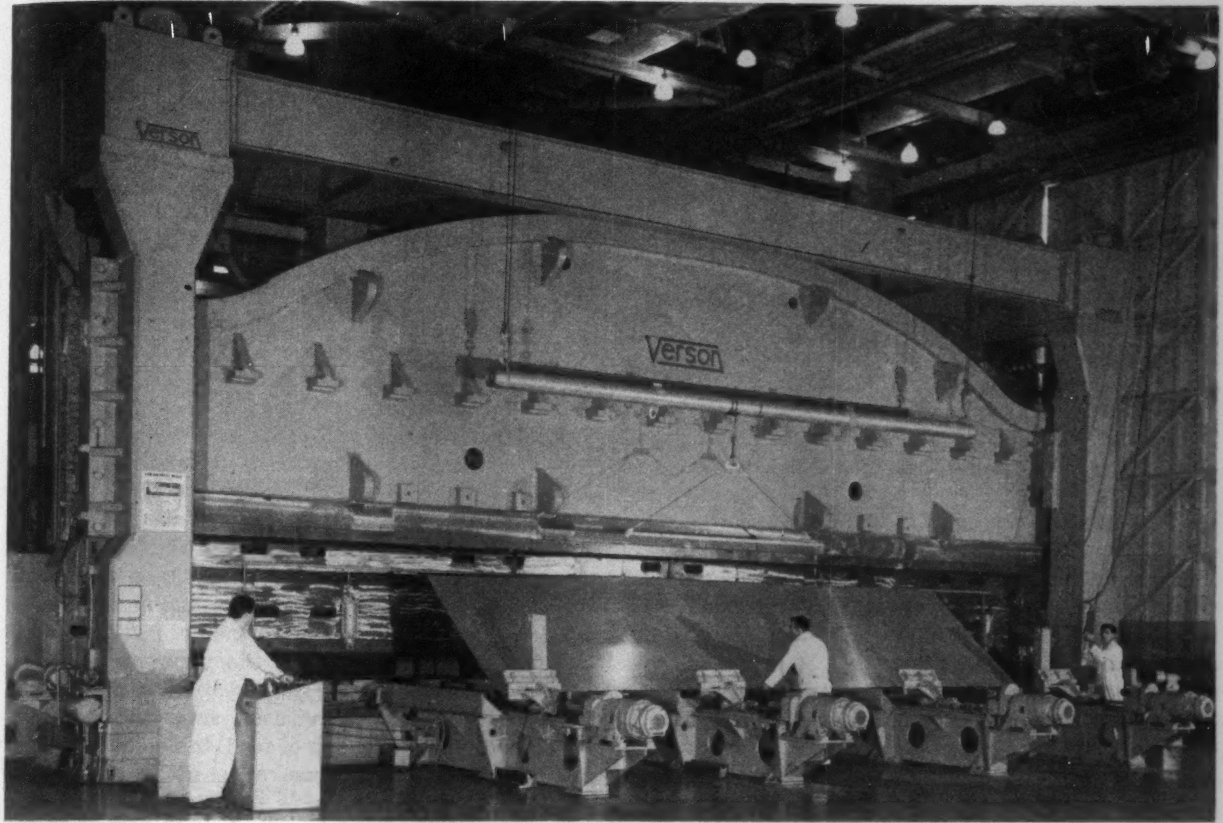
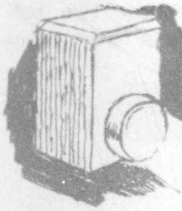


Fig. 1—Size of hydraulic press brake reflects the emphasis in air frame manufacture on integrally stiffened parts. Automatic control features of press include feeding work in desired increments and adjusting a mechanical stop at each end of the press to obtain a desired tilt to the ram, i.e., the relative position of the extreme ends of the movable male die as it penetrates female die.



## PHOTOCELLS CONTROL

# VERSATILE PRESS BRAKE

**By H. L. REYNOLDS**
Vice President
Hydraulic Press Div.
Verson Allsteel Press Co.

**Photoelectric devices have proved to be one of the more flexible means in obtaining automatic control. New and novel applications are constantly being designed. This article describes the operation of a special press brake and the part played by photelectric devices in making it a unique tool in the air frame industry.**

INTEREST by the aircraft industry in large machines and machine tools reflects a trend in air frame manufacturing favoring large integrally stiffened parts in lieu of riveted and welded assemblies. Of interest to the field of automation are the controls which manufacturers have added to these giant machines to satisfy still another major air frame industry requirement: Equipment must be suitable for both job shop production of development items and large quantity runs of production items.

This feature of versatility is illustrated by the controls which Verson Allsteel Press Co. has incorporated on a special 1800-ton press brake—a part of a fabrication line at the El Segundo plant of Douglas Aircraft Co, Inc. The line is built to handle plates 10 by 40 feet in size. This press brake is the largest press brake of its type ever built as regards size, tonnage capacity and working area. The bolster area is 48 inches by 44 feet and the stroke of the ram is 24 inches.

Complex form is imparted to the work by controlling the feed of the work and depth that a male die enters a female die during each stroke of the press. Work is centrally positioned before the brake and fed through the press by individually motor operated feed tables, *Fig.* 1. Of the four feed tables available, only the two inner or two outer tables are used at one time, depending upon the size of sheet being processed. The amount of feed of each table can be controlled independently.

The work is fed to the press in increments; a single ram stroke being made for each increment of feed. Automatic control of the increment of feed at each end of the workpiece is obtained by means of a photoelectric system actuated by notched steel tape, *Fig.* 2. The ¾-inch steel tape contains notches ½-inch long and ¼-inch wide at specified locations along its length. During operation, as full-width tape passes the light source, the individual feed table motors turn at a normal 3450 rpm. With the first appearance of a notch in the tape, the motor slows down and continues to run at 430 rpm until the notch in the tape exactly divides the light received at the photoelectric cell at which time the motor is braked.

Minimum increment of feed is 1 inch. For 1-inch feed, ½-inch of the tape must be solid with the remaining ½-inch devoted to the notch. In the event that a 6-inch travel is desired, 5½ inches of tape must be solid, with the remaining ½-inch notched.

The stroke of the ram also can be controlled automatically through photoelectric systems. The ram is actuated by two hydraulic cylinders, one at each end of the press, which are independently supplied from separate and matched pumps driven by a single electric motor. Penetration of the male die mounted on the ram is controlled by positioning of mechanical stops under each end of the ram; and it is this positioning which is controlled automatically by the photoelectric systems. The design permits the relative positioning of the two mechanical stops to obtain an overall tilt to the ram of 3 inches.

For the stop-adjusting system at each end of the press there is a photoelectric cell and light source attached to the motor driven adjusting screw assembly which positions the mechanical stop, *Fig.* 3. Between the light source and cell, a job plate (template) is fed horizontally by means of a chain linkage to the workpiece feed whose operation has previously been noted. A two-way clutch at the lead screw of the template carriage is provided to obtain the desired relative movement from the feed table being used, since only one left hand and one right hand feed table, out of the available four, are in use at a given operation. The photoelectric control is designed to follow the top edge of the template and adjust the screw up or down through an amplidyne circuit which controls the adjusting screw motor.

The press also contains one other photoelectric system—a means of indicating to a ram regulating system the relative position of the two mechanical stops. The purpose of this is to measure

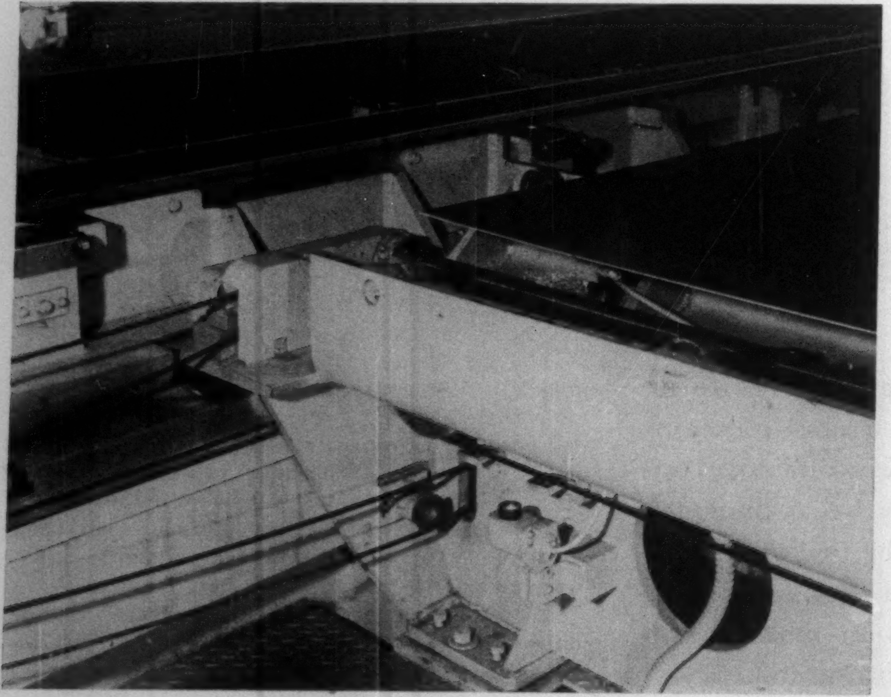


Fig. 2—Automatic control of feed increment is obtained with photoelectric circuits which control individual feed table drive motors. So long as tape interrupts light beam, each feed table motor operates; ½-inch notch in steel tape brakes the motor with work properly positioned to receive a stroke of the ram. This use of a tape control feed adapts the press to production quantity runs.

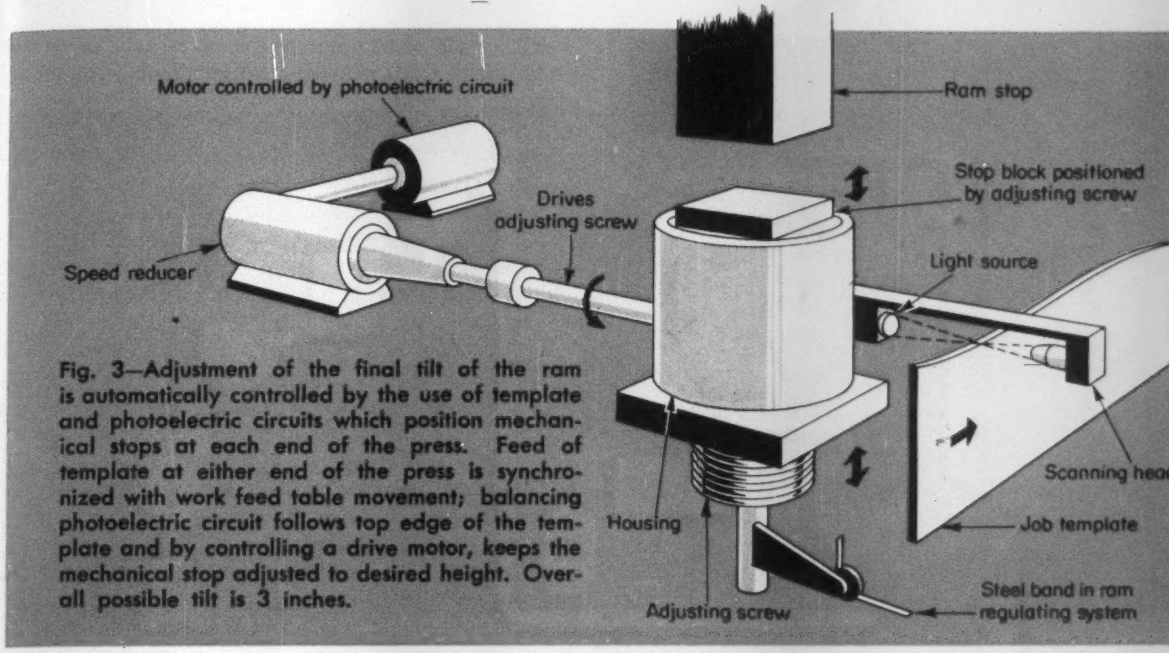

Motor controlled by photoelectric circuit
Ram stop
Stop block positioned by adjusting screw
Drives adjusting screw
Speed reducer
Light source
Scanning head
Housing
Job template
Adjusting screw
Steel band in ram regulating system

Fig. 3—Adjustment of the final tilt of the ram is automatically controlled by the use of template and photoelectric circuits which position mechanical stops at each end of the press. Feed of template at either end of the press is synchronized with work feed table movement; balancing photoelectric circuit follows top edge of the template and by controlling a drive motor, keeps the mechanical stop adjusted to desired height. Overall possible tilt is 3 inches.

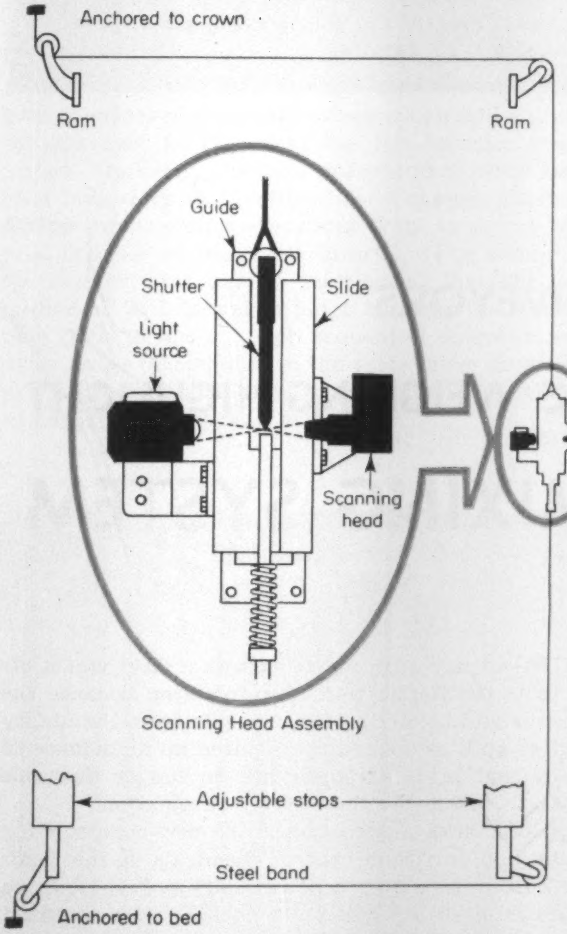

Anchored to crown
Ram
Ram
Guide
Shutter
Slide
Light source
Scanning head
Scanning Head Assembly
Adjustable stops
Steel band
Anchored to bed

Fig. 4—Approximate adjustment of ram to predetermined tilt during stroke occurs automatically as either or both mechanical stops are moved in accordance with template photoelectric systems. Relative movement of stops is reflected in cable connected photoelectric head and light source. This ram positioning regulating system controls the speed of a leveling pump to synchronize the motion of the two ends of the ram during a stroke.

the desired tilt of the ram and control the speed of a leveling pump to regulate the motions of the two ends of the ram during a stroke in order to synchronize the stopping of the two ends. The means of accomplishing this is shown in *Fig.* 4. Any movement of the mechanical stops is reflected by an unbalance in the photoelectric circuit which controls the leveling pump. Adjustment of the tilt of the ram to approximate the relative position of the two mechanical stops brings the light controlled circuit back into balance. The resulting tilt of the ram during the stroke is very close to the tilt demanded by the mechanical stops as positioned by the template controlled adjusting screws.

Another interesting feature of this installation is the provision to support the workpiece as it emerges from the brake. At spaced intervals, four Micarta covered roller chains are strung between the rear of the press and four supports located approximately 12 feet from the press. The heights of the supports can be varied and the free hanging sections of the chains form a curved support to match contoured work,

The operator control equipment is designed to give four modes of operation: (1) Ram only, (2) automatic, (3) manual, (4) jog. The selection is made by a switch on the control desk. The *ram only* position is provided for standard press brake operation without feeds. The *automatic* position provides automatic cycling of stroking, feeding, and stop-adjusting operations. The *manual* position provides for operation in a single-cycle, as indicated for the automatic position. The *jog* position provides independent job operation for the feed and stop drives. Although this press brake was designed primarily for contour forming as described, it can also be used for stretch forming and conventional press brake bending.

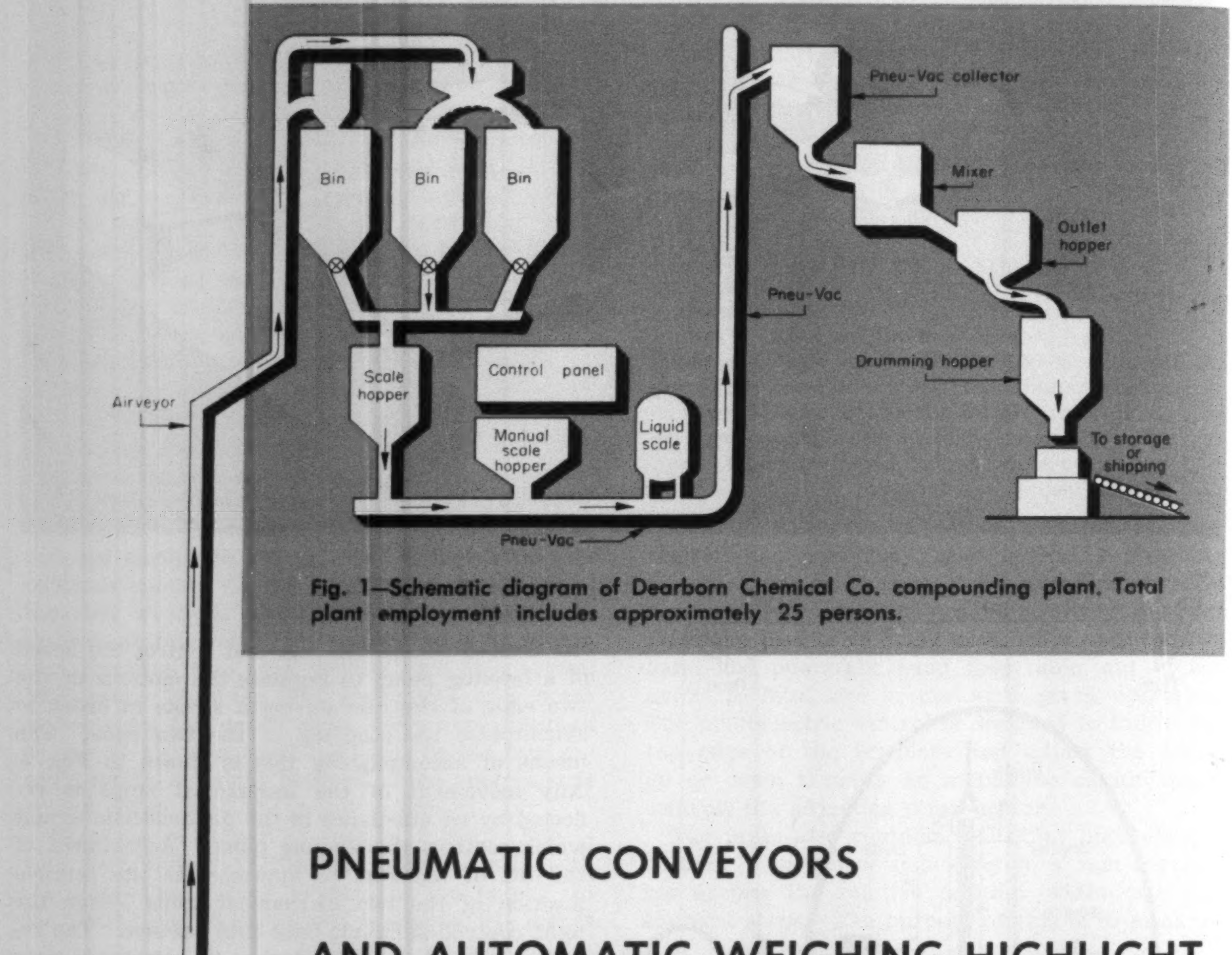

Bin
Bin
Bin
Scale hopper
Control panel
Manual scale hopper
Liquid scale
Airveyor
Pneu-Vac
Pneu-Vac
Pneu-Vac collector
Mixer
Outlet hopper
Drumming hopper
To storage or shipping

Fig. 1—Schematic diagram of Dearborn Chemical Co. compounding plant. Total plant employment includes approximately 25 persons.

# PNEUMATIC CONVEYORS AND AUTOMATIC WEIGHING HIGHLIGHT DRY MIXING SYSTEM

MECHANICAL MIXING of dry bulk ingredients is a field which offers premium gains from the application of automation because the unautomated condition is so literally manual. Aside from the ability to count shovelfuls, the art of bulk compounding required an abundance of muscle. Shovelful accuracy and brute strength are no longer desirable attributes, however, and can be profitably replaced by automation.

An example of this application of automation is the new compounding plant for water conditioning and corrosion control chemicals of the Dearborn Chemical Co. at Lake Zurich, Ill. shown schematically in *Fig.* 1. From the time basic chemicals are received until they are packaged for shipment as compounded products, operation of the plant is almost entirely automatic. Pushbutton control enables plant operators to prepare a complicated chemical formula almost as simply as one might dial a telephone number.

Bulk chemicals are delivered to the plant's railroad siding in either box cars, hopper cars, or tank cars, *Fig.* 2. They are switched from the siding to the receiving dock on the south side of the plant by means of a company-owned Trackmobile. Each car is weighed on a Fairbanks-Morse Scale with tolerances of ±20 pounds.

Other chemicals, raw materials, and mix supplies are delivered, usually by truck, also to the south side of the plant. Thus, all material required for any operation in the plant is received in a common area, helping to maintain a unidirectional flow of material through the plant.

In the case of bulk dry chemicals received in either box cars or hopper cars, material is unloaded by means of three Fuller Airveyors, each capable of handling 10 tons of material per hour. Two of these Airveyors are stationary units servicing 6-storage bins each, and the third is a traveling unit that delivers material to any one of 24-storage bins, *Fig.* 3. In the case of material received in bags, a special device is used which opens the bags and delivers the material to the Fuller Airveyor system.

When small quantities of materials or supplies (or materials whose chemical characteristics are such that they cannot be stored in bins) are received unloading is accomplished by placement of the unit packages on pallets. These pallets are then removed from the receiving dock by electric lift truck and delivered to the properly designated storage area on the plant floor.

Each of the 36-storage bins in the plant has a minimum capacity of one carload. In cases of high density material, the capacity may well run over 100,000 pounds. These storage bins are equipped with interlocked elctrical devices which will cut off the Airveyor in the event the bin becomes overloaded. Similarly, the bins are equipped with low-level indicators that automatically change bin-feed during compounding operations from an empty bin to a full bin of identical material. For example, six storage bins are so interlocked that the sequence of withdrawal is bin 1 through bin 6, and then back to bin 1. Such sequential operation insures usage of material in the same order in which it was received and helps to prevent undue caking or hardening of certain materials.

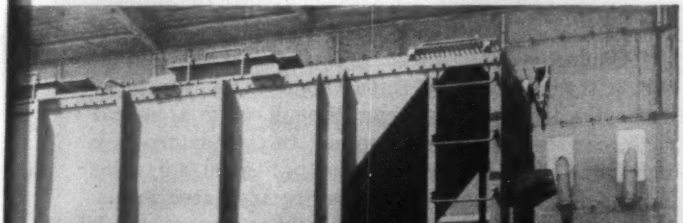


Fig. 2—Unloading a basic chemical shipment from a hopper car. The hose is part of the Fuller Airveyor system used to fill the storage bins.

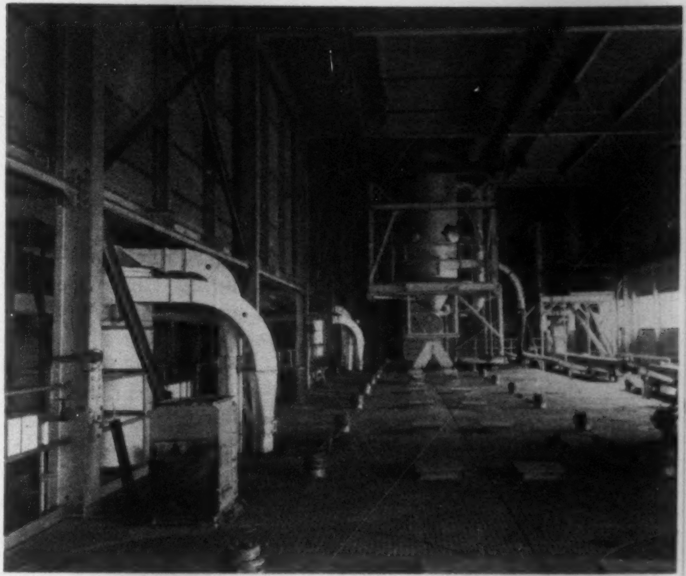


Fig. 3—Traveling Airveyor delivers material to any one of 24 storage bins. The unit moves on overhead rails to the desired bin.

Centrally located within the plant is a Gavan-Graham electrically-operated control panel and a bank of Buffalo Scale Co. weigh-scales, *Fig.* 4. A complete flow diagram of the plant is laid out on the control panel, along with a series of small lights which indicate the flow of material during the compounding operation. After the formula for a given product has been set on the automatic weigh-scales and the control panel activated, the chemicals are automatically fed out of the required bin in the order in which each weight requirement was set on the scales.

Chemicals are fed from the bottom of each storage bin through a rotary vane feeder into a screw conveyor, and then ultimately into an automatic scale hopper. Drive motors for the screw conveyors are of the two-speed type. A reduction in speed occurs automatically when the weight of the chemical being delivered to the scale hopper comes within 50 pounds of the desired weight. With the reduction of the screw feed at this particular point, the remaining 50 pounds are "dribbled" in, thus preventing overweighing of the chemicals required for the formula being compounded.

Where very small quantities of an ingredient are required, the material is dumped manually into a separate scale hopper for inclusion in the compounding operation. Liquid ingredients are automatically weighed in a separate scale hopper for subsequent spraying into the mixer.

There are three scales on each of the two production lines. Two of these on each line are used for the handling of dry materials, and the third for liquids.

After all of the ingredients have been delivered to the scale hoppers and the scales "zero out," the materials are automatically fed into a Sprout-Waldron Pneu-Vac System. They are conveyed through this system to a Pneu-Vac Collector, and from there are discharged directly into the mixer. An Agastat time delay relay circuit is then activated to attain a predetermined mixing time.

At the expiration of the mixing time, the discharge door of the mixer is automatically opened and the 4000 pound batch conveyed directly to one of three drumming hoppers. The hopper to be used for drumming is selected by the operator at the control panel. In the case of some formulations, the material is conveyed from the mixer to an intermediate outlet hopper before being delivered to the drumming hopper.

After the material has been discharged into the drumming hopper, a sample of the compounded product is taken from the hopper and sent to the plant's control laboratory. Here it is completely analyzed to determine adherence to specifications and consistency in quality.

After the product sample has been taken, the product is discharged from the drumming hopper into kegs, drums, or bags, as required. When filled to the correct weight, these containers are then moved on roller conveyors directly to freight cars or trailers at the shipping dock on the north side of the building. The packaged product is then ready for shipment to the customer, or delivery to finished stock inventory.

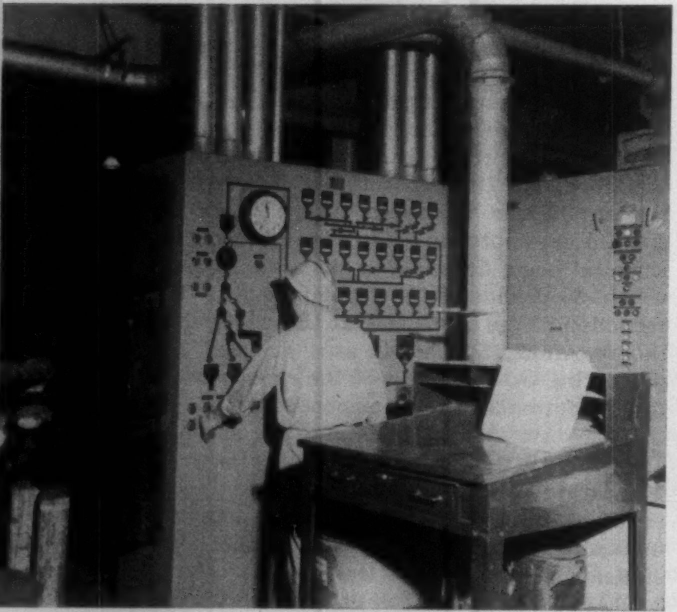


Fig. 4—Electrically operated control panel which operates in conjunction with a bank of Buffalo automatic weigh-scales. When a product is to be compounded, the weigh-scales are set and the control panel activated. Chemical ingredients are then fed from the proper bins and the compounding operations proceed automatically.

# PORCELAIN ENAMEL

**By W. L. SMART**
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NEW PROCESSES developed in fields that are already considered automated point up the fact that we can never determine "the ultimate" in automation. Such is the case in spray painting; after witnessing many system improvements which might tend to take development impetus from this area, we find that the electrostatic spray painting approach has added further improvement. Manufacturers must guard themselves against thinking that they have the ultimate—once they begin to think that they do, they won't for long.

In connection with planning of manufacturing facilities for Appliance Park, the superintendent of finishes for the General Electric Home Laundry Department requested that Ransburg Electro-Coating Corp. work with General Electric on use of the No. 2 Electrostatic Spray Process for applying porcelain enamel to washer and dryer parts. Chicago Vitreous Enamel Products Co. provided facilities for preparing samples of milled enamel and suggested the Hegman gage as a convenient and accurate means for measuring fineness of grind. Ingram-Richardson Inc. provided valuable assistance throughout the development, especially insofar as the slip materials and mixtures were concerned.

After completion of the development program, G.E. was able to gradually increase its output as personnel became more familiar with enamel shop practices. G.E. now processes almost a million square feet of cover coat each month.

The electrostatic spray process as it is used in G.E.'s Home Laundry Department is shown schematically in *Fig.* 1. A conveyor having a helical path carries the ware around the rotating disk atomizer. The voltage pack supplies 90,000 volts dc to the disk through a heavily insulated cable. This same cable supplies three-phase power which operates the disk rotating motor.

Slip is supplied from above and to the center of the 20-inch disk by specially designed diaphragm pumps from electrically isolated storage tanks. Centrifugal force carries the slip to the disk edge where it is atomized under the influence of the electrostatic field and deposited on the electrically grounded ware. A stationary plastic disk prohibits excessive air movement from the edge of the rotating disk.

Repelling electrodes surround the loop outside of the ware and are also charged to 90,000 volts dc. The electrostatic field between these electrodes

# APPLIED ELECTROSTATICALLY

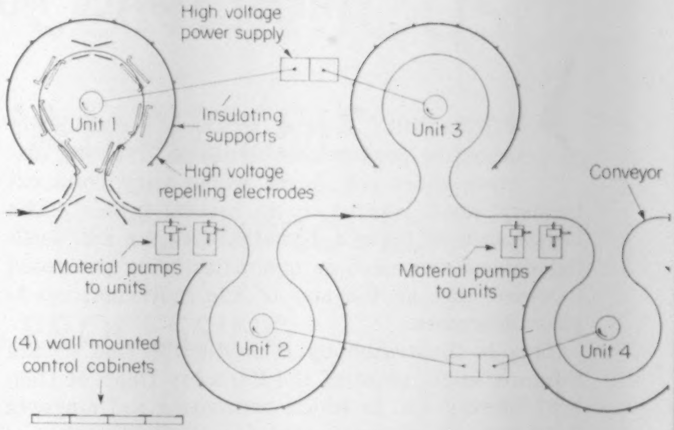


Fig. 1—Schematic diagram of the four-station electrostatic spray painting installation at Appliance Park. One operator and three touch-up men are required for the system.

and the grounded parts repels any small amount of atomized material which may carry through between the parts. This not only confines the sprayed porcelain particles to the loop coating area, but also assists in depositing cover coat on the electrostatically shielded flanges.

Ware enters the first loop at the bottom of the spiral, and proceeds clockwise around the disk, *Fig.* 2. The helical conveyor carries it upward around the loop, which permits the application of an extremely uniform coating from top to bottom. In the second loop the ware moves counter-clockwise around the disk to apply a coating to the work on the opposite side of the hanger. Here, each part enters the loop at the top, and the spiral conveyor lowers it as it circles the disk. Then the articles hanging from each side of the workholder proceed around spiral loops 3 and 4 to receive a second and final coat. This coat is then dried as the ware passes through a convection oven. In the dry bisque state the parts are brushed as necessary, inspected, and transferred to firing tools on the furnace conveyor.

Besides white, the G.E. Home Laundry Department sprays all five of their other standard colors with this equipment—yellow, pink, turquoise, blue, and brown. The same improvement in quality and the same reduction in spoilage or scrap has been experienced.

Based on average performance, it is estimated that approximately three times as many parts per gallon of slip are coated electrostatically as would be coated by ordinary air spray. About 97 per cent of the atomized enamel is deposited on the ware; after 17 hours of operation, almost no enamel can be found on the floor.

Weight of applied enamel was reduced from about 33 grams per square foot to approximately 23. This was possible primarily because of improved coating-thickness uniformity. The industry considers it necessary to apply a minimum of 18 grams per square foot to obtain complete hiding. It is hoped, therefore, that further reductions in film thickness may be achieved.

Also, appearance and chip resistance are greatly improved. Equipment maintenance is negligible, and as there is no enamel overspray to be exhausted, the air make-up and heat loss are reduced. The process affords a wide range of production rates; for instance, with one disk atomizer it is estimated that ware about 30 inches in height can be coated at any conveyor speed up to 20 feet per minute.

Continuing development work has been directed particularly toward improving the flexibility and ease of adjustment for various sizes of products. It was recognized that this condition would be greatly improved if the vertically reciprocating disk could be used. Companies in the major appliance industry have conducted tests and formulated plans for the installation of new porcelain lines which include reciprocating disks for the application of both ground and cover coats to their major appliance parts.

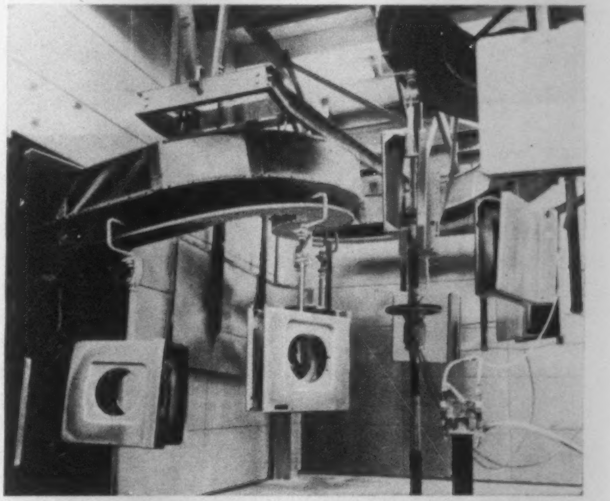


Fig. 2—Porcelain enamel is applied to G. E. appliance parts which are hung two to a workholder. Fixtures are spaced on 40-inch centers and the conveyor line operates at 9 fpm. Almost a million square feet of cover coat is applied per month.

# VIBRATORY HOPPERS SPEED SMALL MAGNET PRODUCTION

VIBRATORY feeding techniques are ideally suited to production operations involving discrete short rod forms which vary from extremely small lengths up to several inches. The importance of these automatic orienting and feeding devices increases as quantities being processed increase, and as the size of the individual workpiece decreases.

This is illustrated by a production line at the Edmore, Mich. plant of the Carboloy Dept. of General Electric Co. in which permanent rod magnets 3/16-inch in diameter by 1 inch in length are manufactured. After an initial casting operation, four main manufacturing procedures are involved in the production sequence: Two grinding operations, heat treating, and final mechanical and magnetic testing. Other functions such as sorting and rejecting, the conveying and positioning between the main operations are handled entirely by vibratory hoppers. Production rate of the tiny rod magnets used in the manufacture of refrigerator doors, cabinet latches, pencils, walkie-talkies, and pot holders is 40,000 per day.

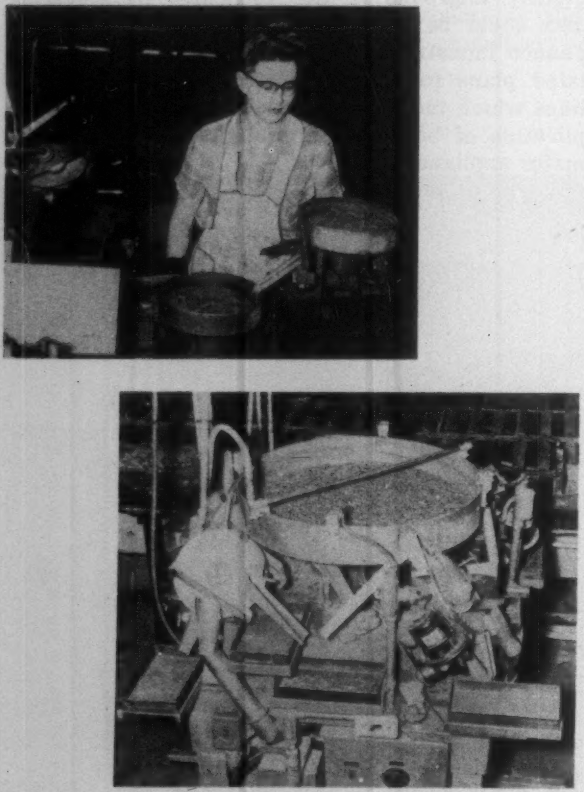


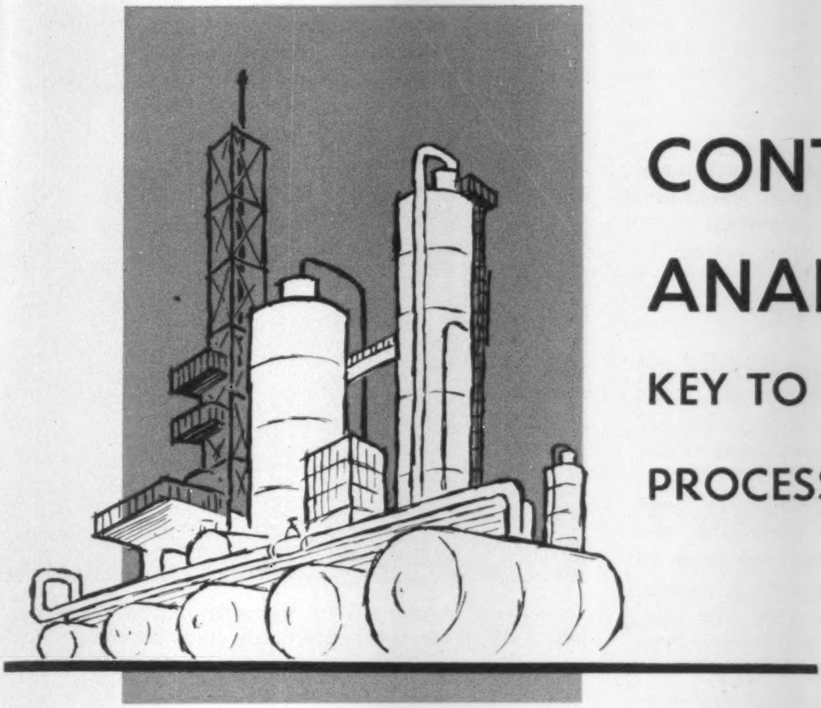
Fig. 1—Acceptable rod castings are separated from unacceptable castings and fed into grinding machine in initial production step involving two vibratory hoppers. After OD is ground, magnets are separated as to length by large vibratory feeder installation which simultaneously services four small identical automatic sizing stations.

The initial application of vibratory feeders in the process line involves two hoppers in a series arrangement as shown in *Fig.* 1. The first hopper separates unacceptable parts as cast, and feeds the acceptable castings to a second hopper which feeds the work down a narrow gravity chute to an initial grinding operation. At this point, only the outside diameters of the magnets are ground after which the rods are dropped into trays.

These trays are emptied from time to time into a second main vibratory feeder application which is designed to service four stations. Three identical sorting functions are performed at each station. The individual parts are fed into a motorized carrier wheel which permits the part to be gaged as to length. For example, the wheel is so designed that if magnets are too long, they protrude beyond the periphery of the carrier and are automatically flipped off by a blast of compressed air. Those which are too short drop off into a second tray and the acceptable magnets are collected in a third tray. In continuous operation, the single four-station sorter is capable of sorting about 20,000 pieces per hour.

Trays containing magnets accepted by the sorter are then emptied into a vibratory hopper near the second grinding operation. The parts are fed by the hopper into the grooved periphery of a wheel shaped fixture and are locked in place by a chain which travels over and in the same direction as the wheel. Once locked on, the carrier wheel conveys the magnet between two slowly revolving grinding wheels which grind both ends of the magnets simultaneously. Approximately 5000 magnets can be ground every hour.

As the units come from this second grinder, they automatically drop into tote boxes which are picked up periodically and transported to the heat treating area. Here, the units are placed in a container on a vibratory base which, through vibrating action, lines up the magnets in the containers which are used to carry the work through the heat treating furnace. The units are then conveyed to a testing station. Two vibratory feeders are used at this point at which both mechanical and magnetic testing takes place automatically. Mechanical tests include means of gaging length, outside diameter, end squareness, etc. Parts passed in the mechanical test are magnetized to a desired energy level and tested as the final operation.



# CONTINUOUS ANALYSIS

## KEY TO IMPROVED PROCESSING

**By J. J. COMBES**
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**Stream processing operations as in refineries and chemical plants have long been adjusted by control of physical variables—temperature, pressure, flow, etc. Periodic laboratory analyses eventually told the operator what he really wanted to know—"Does the product meet specifications?" Analyzers are now available so that operation control can be based on continuous knowledge of product composition.**

UNTIL FAIRLY RECENTLY, the progress of automation in process plants, both petroleum refinery and chemical had reached only the point of automatic control of process variables such as temperature, pressure, flow, liquid level, etc. The holding of these and a few less common physical variables constant at an initially correct control point usually resulted in the production of end products of the required purity and at maximum yield. However, this inferential method failed during uncontrollable changes which are frequently taking place in plant processes: change in composition of the feed streams, change in catalyst activity, change in ambient conditions, and accumulation of impurities. When any of these take place, some of the previously mentioned control points for process conditions become incorrect and must be reset.

It used to be that the results of these changes were not detected until a laboratory analysis was run. By the time test results were available, considerable off-specification material could be produced. If this was sent to product storage, considerably more material might be spoiled or require re-purification. Even if off-specification material was not produced, it was almost certain that the yield would decrease and therefore raw material would be lost.

Now, by the correct application of continuous analyzers, testing delay is eliminated and the major part of product spoilage and raw material waste is prevented. Continuous analyzers sense and record or indicate changes or their results, depending upon the type of change, and the operators are alerted to make the necessary control point adjustments before significant damage is done.

As used in this manner continuous analyzers are actually new. They are very sensitive and accurate primary elements as evidenced by the fact that analyzers can easily detect the presence of impurities in the range of parts per million. That is long before their presence could be inferred, if it could be inferred at all, by process measurements of temperature, pressure, flow, liquid level, etc. obtained with conventional primary elements.

## ▶ Where to Analyze Continuously

Points of application of continuous analyzers and their corresponding functions in a process plant are highly diverse and more are being developed continually. Some of the more obvious applications are :

*On inlet feed streams*: Upon changes in their composition the operator can vary their flow, the flow of inlet air, steam or other material feeds to maintain the process balance of reacting components. This application could be used for gas-steam ratio control on the feed of a reformer type ammonia plant.

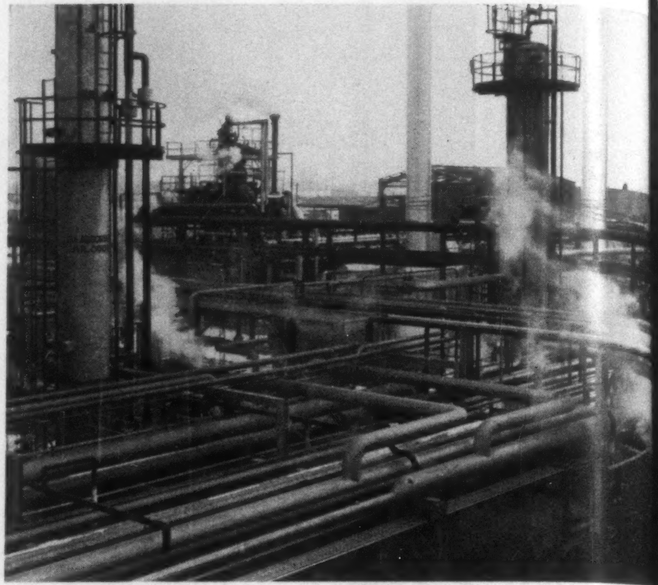
*On the outlet of absorbing or scrubbing systems*: To detect their failure to remove contaminating materials which if allowed to continue in the process could poison process catalysts or produce a contaminated product. The corrective action applied would usually be to recirculate the process stream for further treatment or to increase the flow of treating material. This application has been used on carbon dioxide and carbon monoxide removal systems where monoethanol amine and copper ammonium acetate solutions are the scrubbing mediums.

*On reaction systems to show a dangerous concentration of reactants which could explode or cause the reaction to run away*: Here the flow of reactants could be varied to correct the condition or the process could be flooded with a quench or inert blanket to stop the reaction. This is one of the first analyzer applications and was used on the ethyl benzene to styrene step in a wartime styrene plant of the synthetic rubber program.

*On the outlet of reaction systems to show a change in activity of the catalyst*: This can usually be compensated for by adjusting the reaction pressure or temperature until the catalyst has declined in activity so that it must be replaced or reactivated. Analyzers for this purpose have been installed on the circulating stream of the ammonia reactors in ammonia plants.

*On the circulating process stream in a reaction system to show the accumulation of inerts*: The usual corrective action is to bleed off inerts at a controlled rate until their concentration is no longer above the acceptable limits. Such an application has also been installed on the circulating stream of the ammonia reactors in ammonia plants.

*On product streams to detect off-specification product*: Here it is possible to detect the trend of the product going off specification and by making the correct adjustments to the process controllers the operator can prevent this. The exact nature of these changes will, of course, be dependent upon the process itself. In the event the operator is unable to prevent the product from going off specification he can divert the flow from product storage to an off-specification product holding tank to prevent the contamination of acceptable product until the process has been corrected. The off-specification product can be held for repurification and recovery or ultimate disposal. This has been used on a super fractionator producing high purity hydrocarbons such as a pentane fractionator producing 95 per cent isopentane.



This ammonia plant is an example of the processing plants which can profitably apply continuous analyzers.

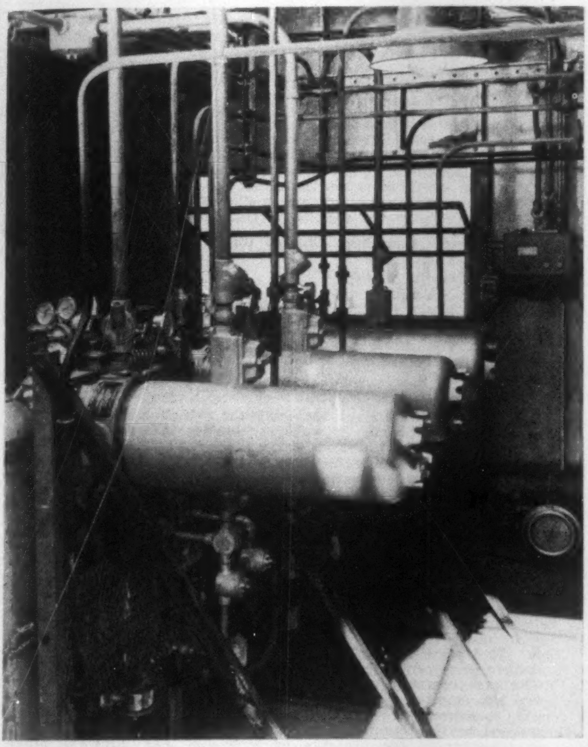
*On plant atmospheres to detect toxic or explosive conditions*: In this case the analyzer will usually not make any changes in process conditions but will sound alarms, start blowers or take other precautions to protect personnel and equipment. This has been used on methanol plants to detect and warn of the presence of carbon monoxide.

## ▶ Available Analyzer Types

A recent survey revealed that many types of analyzers are available. Most of them operate continuously, are of rugged construction for plant use, may be installed out in the weather, are explosion-proof, are insensitive to vibration and are made up of "plug-in" components for easier trouble shooting and maintenance. Brief descriptions of various types of analyzers which are available are included in TABLE 1.

Additional different types of analyzers will gradually become available as manufacturers develop instruments that will operate on the basis of other chemical or physical characteristics or effects of the various subtances that are to be analyzed for.

There are other more simple types of instruments which can be classed as end point analyzers. They can be used to determine solution strengths, concentration of heavies in tower bottoms, process contamination, blanketing atmosphere conditions, etc. Some of these are instruments for measuring liquid and gas specific gravity, gas dew point, liquid turbidity and viscosity, vapor pressure, partial pressure, boiling point rise of solutions, etc.



Three infrared analyzers (foreground) and a colorimetric analyzer (on wall) are part of the equipment used in control of the ammonia plant example.

## ▶ Choice of Sampling Points

Analyzers have now been developed to a degree of dependability such that in their use more trouble is encountered in the sampling systems than in the analyzers themselves. However, good engineering of the sampling systems can eliminate most of this trouble.

Although the characteristics of each individual process will determine which samples might best be taken for analysis, there is usually a choice as to the physical location of the sample point. The sample point should be chosen to satisfy as many as possible of the following requirements:

1. Most important is that the sample point must be chosen so that it will provide a sample that is representative of the composition of the process stream that is influenced by the control action.

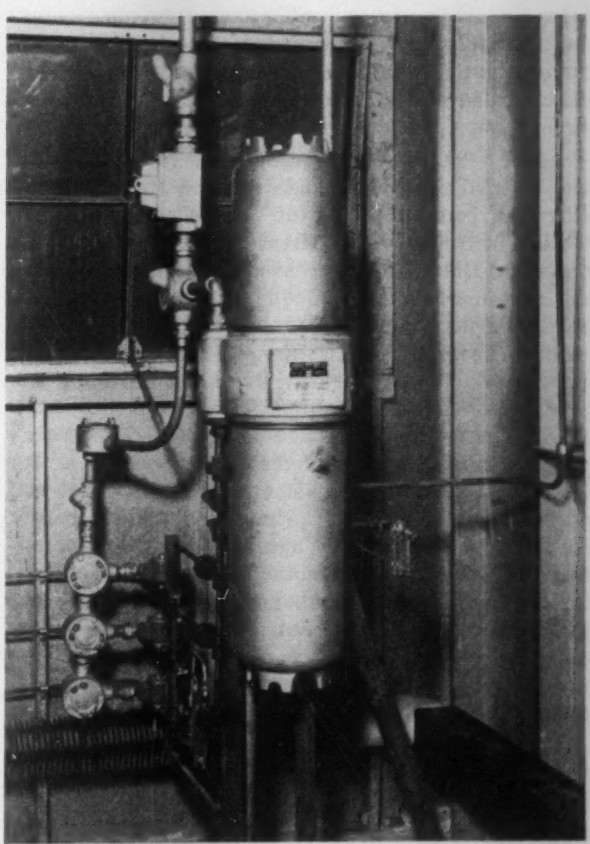
2. The sample point chosen should provide the minimum of transfer lag both from the point of application of the control action to the sample point and from the sample point to the analyzer itself. Although it is always better to mount the analyzer near the sample point sometimes circumstances dictate that the sample point and analyzer be widely separated. In this case the resulting lag can be cut down by providing a rapidly flowing sample to the analyzer location bypassing back to a lower pressure point in the process with a short sample take-off from the sample bypass line to the analyzer.

3. Sample points should provide clean, dry samples to eliminate as much as possible the need for the use of filters, driers, knockout pots, steam tracing, etc.

4. A sample point should provide a sample at moderate conditions of pressure and temperature so as to eliminate as much as possible the need for pressure reducing valves, sample coolers and sample heaters.

## ▶ Applying Continuous Analyzers

It is good policy to require that the analyzer vendors supply with their analyzers all equipment required to condition and regulate the sample from the process so that it can be accepted by the analyzer. Such equipment includes pressure reducing valves, sample coolers, sample heaters, filters, driers and solenoid valves (for switching samples on units analyzing more than one sample). Supply of conditioning equipment with the analyzer is advantageous in that it increases the probability of



This thermal conductivity type analyzer for hydrogen is also installed in the analyzer house of the ammonia plant.

the instrument receiving a correctly conditioned sample and practically insures a satisfactorily performing instrument.

To assist the vendor in providing equipment to correctly condition the sample and to properly calibrate his instrument, the buyer should supply complete information including: Process pressure and temperature at the sample point; complete composition of the sample including water or other vapors in gas samples and gas and immiscible liquids in liquid samples; sample cleanliness in regard to dust and solid particles; maximum and minimum ambient temperatures; distance between analyzer and recorder or controller; average barometric pressure at the geographical location where the instrument is to be installed.

Continuous, automatic analyzers are now almost universally accepted as accurate, dependable, industrial instruments. Their maintenance has been made simpler and is now, in most cases, well within the capabilities of a good, experienced instrument mechanic provided he has had training by the manufacturer of the analyzer for whose maintenance he is responsible. Costs of the various types of analyzers are decreasing with their increased production and use and because of competition among the various analyzer manufacturers.

These developments have led to the use of analyzers as controllers. Of course pH instruments have been used as controllers for years and there have been papers published describing the use of infrared analyzers and differential refractometers as controllers. Undoubtedly other applications have been made in which analyzers have been used as controllers both in direct and cascaded applications.

At present the advantage seems to lie with the use of analyzers in cascade control, that is, resetting the control points of primary process controllers rather than in direct control. Such use is based on the following reasons: Sample conditioning systems may be inadequate, and until they are corrected may cause the analyzers to occasionally be out of service. With the analyzer out of service, automatic control is still available through the primary controller. Automatic control is also available when the analyzers are being zeroed and calibrated. In addition, changes in process or utility flows or pressures can sometimes be detected and corrections made by the primary controllers before they have had time to actually change the analysis. Such a case is similar to having a flow controller for steam to a reboiler reset by a temperature controller rather than controlling the steam directly by the temperature controller. Corrections for changes in steam pressure may thus be made before the temperature is affected.

Using analyzers as cascade controllers rather than as simple recorders eliminates the requirement that an operator observe their record and manually adjust control points of controllers as the necessity of adjustment is shown by the recording analyzer. Analyzer controllers also make the adjustments immediately and correctly.

## TABLE 1

## Available Types Of Continuous Analyzers

- **Carbon Dioxide Absorption:** The flowing sample is divided into two streams from one of which the carbon dioxide is absorbed in the analyzer. Analysis is based upon the resulting difference in pressure between the two streams.

- **Catalytic Combustion:** This equipment measures the increase in temperature, as indicated by an increase in resistance, of a heated platinum filament as the sample containing the combustible material flows across it at a controlled rate. The rise in temperature is proportional to the per cent of combustibles present.

- **Colorimetric:** Measures change in intensity (lightness to darkness) of color of the sample itself or of a reagent which is color sensitive to the material being analyzed for. The change in color is proportional to the per cent concentration of the material analyzed for in the sample.

- **Dielectric Constant:** Change in dielectric constant is proportional to the change in concentration of the material being analyzed for in the sample.

- **Differential Refractometer:** The index of refraction of the process sample is compared with that of a known reference sample. The difference in the refractive indices of the two samples is therefore a function of the purity of the sample being analyzed.

- **Electroconductivity:** Material for which analysis is made either ionizes directly in water or ionizes in water after being decomposed by heat and catalyst. The change in electroconductivity of the water is measured, and is proportional to the per cent concentration in the sample of the material for which analysis is being made.

- **Hydrogen Diffusion:** A sample containing hydrogen passes over a palladium tube at a controlled or accurately measured pressure. The hydrogen diffuses through the palladium tube and a pressure gage calibrated in absolute pressure units indicates the pressure of the hydrogen in the tube. This pressure is the partial pressure of the hydrogen in the sample.

- **Hydrogen Ion (pH):** These instruments measure the hydrogen ion concentration or the acidity of water solutions. The measurement is expressed numerically in pH units, which are the negative logarithm of hydrogen ion concentration. The pH measurement is accomplished with two electrodes immersed in the sample solution. One, the measuring electrode, is sensitive to the presence of hydrogen ions; and the other, the reference electrode, completes the electric circuit through the sample and supplies a constant potential. The glass electrode, which is now the most universally used measuring electrode, operates on the basis that when a thin membrane of special glass separates two solutions of differing hydrogen ion concentrations a potential is generated that is a function of the difference in the two concentrations. If the pH of one solution is held constant (the constant pH solution is contained inside the electrode tip) that of the other solution (the unknown sample) can be determined from the potential produced. The most widely used reference electrode is the saturated calomel electrode which is comprised of mercury and mercurous chloride with saturated potassium chloride as the electrolyte.

- **Infrared:** Two styles of infrared analyzers are used. The positive type instrument measures the absorption of infrared energy by the process sample and compares it with the absorption of infrared energy by a pure reference sample of the material being analyzed for, or of a reference sample whose concentration of the material being analyzed for is equal to the maximum range of the instrument. The difference in infrared absorption is then inversely proportional to the concentration of the material being analyzed for in the process sample.

  The negative type instrument measures the amount of infrared energy transmitted through the process sample and compares it with the infrared energy transmitted through a pure reference sample of the material being analyzed for, or a reference sample whose concentration of the material being analyzed for is equal to the maximum range of the instrument. The difference in infrared energy transmitted through the process and reference samples is then inversely proportional to the concentration of the material being analyzed for in the process sample.

- **Mass Spectrometer:** There are several types of mass spectrometers but all operate on the principle of sending a small stream of the sample into a high vacuum, ionizing it, accelerating the ions to high velocity and passing the ion stream through magnetic, electric or electrostatic fields. The fields act upon the ions and separate them by deflecting their paths or changing their velocities in inverse proportion to their masses. By adjustment of the instrument, ions of a given mass can be made to impinge upon a collector plate and produce an electrical signal proportional to the quantity of those ions present.

- **Oxygen Magnetic:** There are two different types of oxygen analyzers which depend upon the strong paramagnetic property of oxygen for their operation. One type measures the difference in temperature of two heated filaments as indicated by their difference in electrical resistance. One filament is in a strong magnetic field and one is not. The oxygen in the sample, being strongly paramagnetic, is drawn to the heated filament in the magnetic field, where it becomes heated, loses its magnetism, and is displaced by fresh, unheated oxygen. This flow of oxygen cools the filament in the magnetic field and the difference in temperature between the two filaments is proportional to the per cent concentration of oxygen in the sample.

  The other type measures the change in the magnetic force acting upon a test body which is suspended in a nonuniform magnetic field and is surrounded by the sample gas. The oxygen in the sample is attracted into the magnetic field and tends to displace the test body away from the strongest region of the magnetic field. The instrument is sensitive to this deflection and automatically varies the electrical potential of the test body to produce an electrostatic force of sufficient strength to hold the test body in the strongest part of the magnetic field and overcome the displacement force of the oxygen. The potential required to hold the test body in this position is a direct measure of the oxygen content of the sample.

- **Oxygen Polarization:** This instrument consists of a primary cell with metallic and hollow carbon electrodes immersed in an electrolyte. The sample to be analyzed is passed through the hollow carbon electrode by diffusion. Hydrogen is evolved at the carbon electrode causing polarization in the cell which decreases the generated voltage and current. Oxygen contained in the sample, diffusing through the wall of the carbon electrode, combines with the hydrogen and causes depolarization. Therefore, the more oxygen the sample contains the more depolarization takes place, and the higher is the electric current generated by the cell.

- **Radiological:** This instrument is used for the continuous analysis of binary gas mixtures, and emphasis has been placed on its use to measure the build-up of inerts in ammonia synthesis plants. Ammonia and hydrogen, which would interfere with the analysis, are removed from the synthesis gas sample. The measuring unit consists of two ionization chambers. One is continuously purged with the sample of nitrogen and argon, and the other is purged with pure nitrogen. The gases in the two chambers are ionized by beta particles. After adjusting the difference in ion current of the two chambers to zero with only nitrogen in both, the sample containing argon is passed through the measuring chamber. The argon in the sample increases the measuring chamber ion current and the difference in ion currents from the two chambers is then proportional to the concentration of argon in the sample.

- **Spectrographs:** There are a number of different types of spectrographs such as Optical Emission, X-Ray Fluorescent Emission, Nuclear Magnetic Resonance, etc. They usually operate by indicating the wave lengths and intensity of energy emitted by the sample when under excitation. The wave lengths indicate the elements or compounds present and the intensity indicates the concentrations present. Spectrographs are mostly used to analyze solids.

- **Spectrophotometer:** This equipment compares the absorption spectrum of the unknown sample, and its intensity, with that of a known sample. The unknown sample is thus identified.

- **Thermal Conductivity:** Thermal conductivity of the unknown sample is compared with the known sample. The thermal conductivities of the samples are measured by their ability to carry heat away from, and therefore change the resistance of, heated electrical filaments. Comparison of the resistance of the filaments in the unknown and the known samples therefore is in effect a comparison of their thermal conductivities. Using this measurement the instrument can be calibrated to read the per cent concentration of the material being analyzed for in the sample. These instruments are used to determine the per cent concentration of substances whose thermal conductivities are considerably different from that of the rest of the components of the sample, and they are very specific for hydrogen.

- **Ultraviolet:** This device is similar to the infrared analyzer except it measures the absorption of ultraviolet radiation instead of infrared. Such units are used to analyze for materials that are better absorbers of ultraviolet energy, or in samples where the interfering components in the sample do not absorb ultraviolet as readily as they do infrared. Interfering effects are thus minimized.

## Future Possibilities

A future step may be the use of analyzers sending information to a computer which will, on the basis of this information, adjust to the correct degree the control points of the affected process controllers to provide corrective action and keep the process producing on-specification material at the required rate. The computer might also make process control point adjustments based upon information supplied to it by other nonanalytical instruments monitoring ambient conditions and utility changes. The computer might be provided with the applicable mathematical relations for the plant economy, process, and process equipment in order that it could make the correct control point adjustments for the signals supplied to it by the analyzers and the other monitoring instruments. This would eliminate all possible lag between the time the analysis changes and the corrections are made, and it would also theoretically eliminate the possibility of incorrect adjustments such as could be made by an operator under the stress of emergency conditions.

A major roadblock in the achievement of this goal is the determination of the applicable process steady state and transient relationships that the computer would be guided by in making the control point adjustments based upon the signals it receives from the analyzers and the other monitoring instruments. To obtain the dynamic behavior of a plant's process and equipment to produce a specific material at the plant's location and with the feed materials available will require considerable work in the realm of higher mathematics and process studies as well as futher computer development. When the overall relationships are developed for a given plant they will almost certainly have to be modified, at least to the point of supplying new constants, in order to use them for another plant of the same kind because of the effects caused by differences in composition of the feed streams, differences in the characteristics of the cooling water, differences in atmospheric conditions, mechanical differences in process equipment and other differences which always exist between two process plants producing the same product but built at different times and at different locations.

Use of continuous analyzers to feed information to computers in resetting the control points of the conventional process controllers will probably be attained gradually. First it may be done on a single simple item of process equipment such as an absorber, then on a process system such as a distillation column with its reflux drums, reboilers, condensers, etc. Finally, we may come to the use of continuous analyzers as master controllers to reset the control points of a plant's primary controllers through a computer. Until that time arrives, continuous analyzers will be used where they have established their worth for manual and automatic control in processing operations either directly or through adjustment of a primary controller.

# INTERFLOOR TRANSFER SYSTEM SPEEDS PRODUCTION

UNCOMPLICATED automatic equipment exists which can aid the multifloor plant in solving a persistent production problem created by architecture—interfloor handling of material. This type of equipment is especially needed in plants with automated facilities as increased production leads to material movement which outpaces the random type of traffic for which freight elevators are designed.

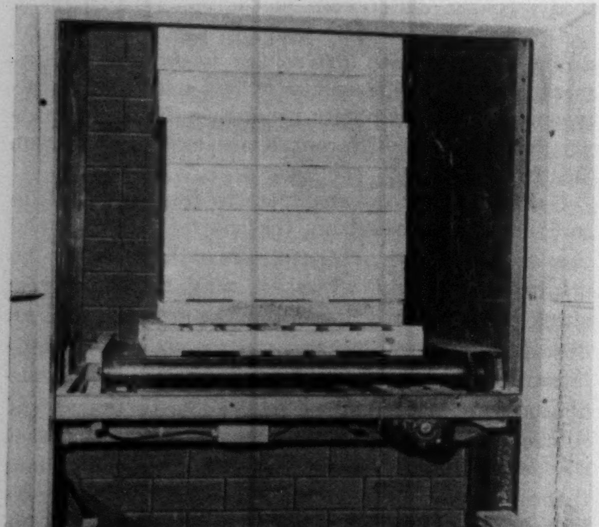
As an example, rapid expansion in the production of both color and black and white TV sets made it impractical to handle the volume of interfloor traffic with existing freight elevators at RCA's assembly plant in Bloomington, Ind. To enable continuous flow of components between floors and to eliminate elevator congestion, the company installed an automatically controlled, reversible interfloor handling system manufactured by Gifford-Wood Co., Hudson, N. Y. The system carries pallet loads of a wide variety of TV components—tubes, speakers, resistors, condensers, chassis, wires, yokes, sockets, terminal strips, stampings, etc.—between first floor storage and basement assembly areas.

The system comprises a carriage, or gig, which operates vertically between floors, and two horizontal live-roll conveyors which bring loads to and carry them from the gig. The system is entirely self-operating from the time it receives a load until the time the load is removed.

In transferring a load from first floor to basement in this system, the palletized load is placed on the conveyor by fork truck. The load activates a limit switch which operates the first section of the live-roll conveyor and starts the pallet on its way. The carriage is equipped with powered rollers which position the load and as it moves completely into the shaftway, the load operates a switch which lowers the gig to the basement level.

As the gig lines up with the basement conveyor, its rolls are again activated and the pallet moves out onto the basement conveyor. When the pallet reaches the end of the conveyor it is stopped by a structural member and held until a fork truck comes and removes it. As it reaches the end of the conveyor, it automatically raises an air operated stop which will hold back any additional loads until the first one has been removed. The basement conveyor will store two loads. Should a third load be placed on at the first floor level it will be moved onto the gig but the gig will not descend. As soon as the first load is removed, each succeeding load moves up one step. The system operates similarly in the reverse direction as dead-headed pallets or special pallet loads make the reverse trip.

The live-roll conveyors comprise 5-foot long rollers installed with sufficient end clearance to provide for 6-inch load overhang on either side. Main controls are located on the first floor and it is from here that the direction of conveyor travel is determined. Located at both basement and first floor levels, however, are additional buttons which will stop the system, should this be desired for any reason. The first conveyor section travels at 8 ft per minute—a speed slow enough to enable forks of the trucks to withdraw from the pallet without upsetting it. The adjacent conveyor section travels at 20 ft per minute and the gig conveyor at 30, descending at 50 ft per minute.



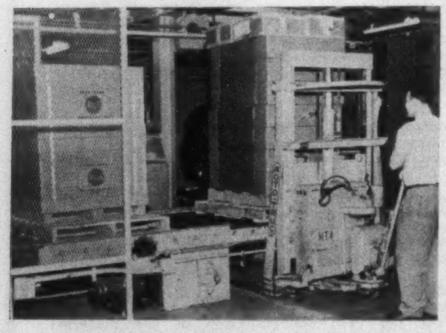
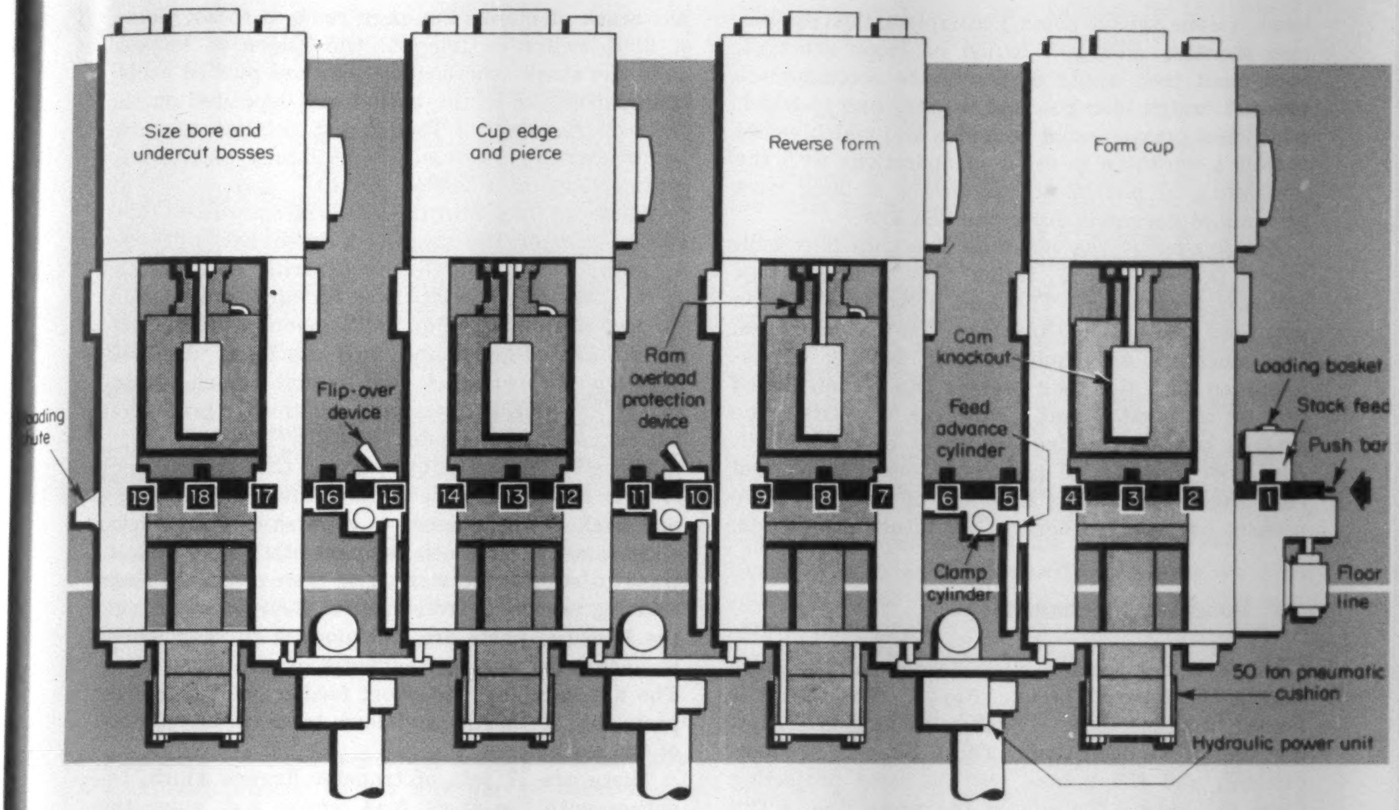


Fig. 1—Interfloor handling system takes over as pallet loads are placed on conveyor. The automatic system provides that loads placed on the conveyor are automatically moved into the interfloor carriage by powered roller conveyor, transported between floors, and discharged by a duplicate conveyor setup. Safety interlocks prevent operation if carriage is not in position to receive load or if discharge conveyor is not free to accept load.


Size bore and undercut bosses
Cup edge and pierce
Reverse form
Form cup
oading
hute
Flip-over device
Ram overload protection device
Cam knockout
Feed advance cylinder
Clamp cylinder
Loading basket
Stack feed
Push bar
Floor line
50 ton pneumatic cushion
Hydraulic power unit
19
18
17
16
15
14
13
12
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1

Fig. 1—This metalworking line consists of four separate presses mechanically linked by feeding devices and having interlocking electric and hydraulic controls for automatic operation as a single integrated unit. Present presses can be rearranged or removed, and additional presses can be added if necessary.

# ELECTROHYDRAULIC HANDLING CONTROL

## IN CONTINUOUS STAMPING OPERATION

A volume producer of automobile wheels wanted equipment which would step up wheel production but could be readily adapted for product design changes or even change of product. With the aid of the press manufacturer a versatile press line was designed which will operate automatically but can also be manually operated. Features of the equipment and controls are described here.

BETTER UTILIZATION of manpower is imperative not only in this country but also in many industries abroad. England, in its post-war boom, has experienced a labor shortage in many phases of its industry. The Dunlop Rim & Wheel Co. of Coventry, England, has been faced with this common problem while experiencing a growing demand for the automobile wheels it produces. A solution to some of their problems has been the development of a flexible press setup which can be operated automatically.

In developing the equipment, Clearing Machine Corp. was asked to provide: means to increase production of auto wheels far beyond the present level, means which could accomplish this production increase during a period of labor shortage, equipment that would be flexible to accommodate product design changes, and a press line to which additional presses could be added and which would permit a variation in order of operations with the possibility of automatic production of long runs or manual operation for small job lots.

For flexibility, the resulting line uses four individual presses, *Fig.* 1, rather than a single large transfer feed press. The lead press is a 275-ton unit and the other three are 600-ton machines. The machines are equipped with feeding mechanisms so that the four presses can be integrated into an automated unit. However, if desired, the presses can be run independently of each other. Also, the line can be physically taken apart and rearranged in automatic units of two or three presses as may be required by future production.

## ▶ Handling Mechanisms

Stock is fed from a stack feeder to this press line in the form of blanks, *Fig.* 2. The feeder is loaded from special steel baskets without interrupting the press operation. These baskets are bottomless, and the blanks rest on cams projecting from the sides. To supply the press line, a full basket of blanks is placed on a pneumatically elevated platform directly above the feed stack. When the stack of blanks has been reduced to six pieces, a limit switch is tripped; the basket is lowered onto the stack; the basket cams are pushed aside; and the blanks in the basket are deposited on the top of the stack. The basket is then elevated to its starting position, where it may be removed and replaced by a loaded basket.

Blanks are fed into the transfer equipment from the bottom of the stack. A push bar, operated by a hydraulic cylinder timed with the transfer feed, slides the bottom blank forward to a positive stop at station two, *Fig.* 3. Components are physically designed to advance only one blank at a time from the hopper stack, but a limit switch is provided at station two as additional protection against feeding a double blank.

Transfer feeding equipment on this line consists of sets of fingers which: move inward from front and back of the presses to clamp the piece parts, slide parts 24 inches to the next station, move outward to release the work, and then return to their starting positions. Over most of their path through the line, the parts are slid along a runway which is flush with the top surfaces of the lower dies. The flat handling and short feed travel reduce the problems of inertia and lead to accurate control of the workpieces.

There are 17 sets of transfer fingers which, together with the stack feed pusher rod, move the parts through 19 stations on the line. All of the transfer fingers act as a unit, but they are actu-

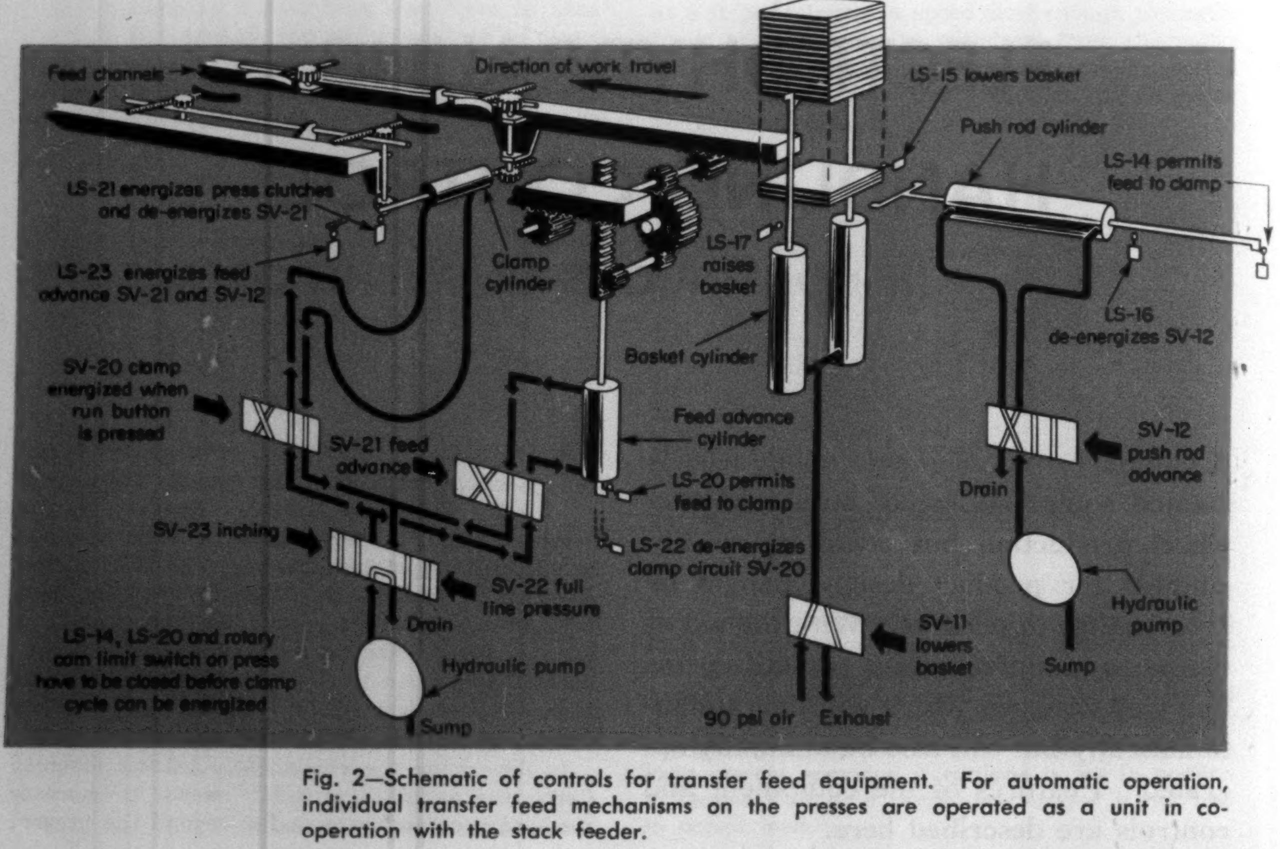
Feed channels
Direction of work travel
LS-15 lowers basket
Push rod cylinder
LS-14 permits feed to clamp
LS-21 energizes press clutches and de-energizes SV-21
LS-23 energizes feed advance SV-21 and SV-12
Clamp cylinder
LS-17 raises basket
Basket cylinder
LS-16 de-energizes SV-12
SV-20 clamp energized when run button is pressed
SV-21 feed advance
Feed advance cylinder
LS-20 permits feed to clamp
LS-22 de-energizes clamp circuit SV-20
SV-23 inching
SV-22 full line pressure
Drain
LS-14, LS-20 and rotary cam limit switch on press have to be closed before clamp cycle can be energized
Hydraulic pump
Sump
SV-11 lowers basket
90 psi air
Exhaust
SV-12 push rod advance
Drain
Hydraulic pump
Sump

Fig. 2—Schematic of controls for transfer feed equipment. For automatic operation, individual transfer feed mechanisms on the presses are operated as a unit in cooperation with the stack feeder.

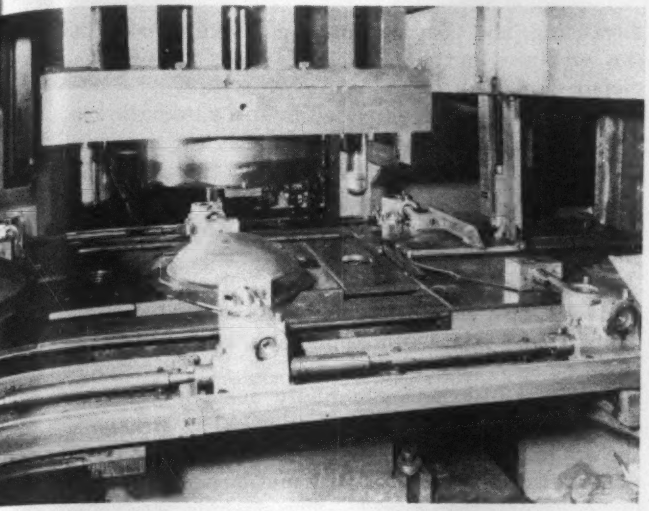

Fig. 3—The blank for an automobile wheel is shown here just after cupping at station three. The feed fingers have moved in to grip the piece part, but the transfer advance to the next station has not yet been made.

ally parts of three individual devices hydraulically and mechanically locked together to function as one. The 600-ton presses are equipped with separate hydraulic power units which actuate their feed mechanisms. In each feed unit a double acting hydraulic cylinder operates a gear rack and drives a pair of channel members in feed advance and return motions. A double acting hydraulic cylinder carried by each pair of feed channels is connected to a series of gear boxes mounted along both channels at 24-inch intervals. These gear boxes drive small gear racks which carry the feed fingers, and these motions clamp and unclamp the workpieces. The cylinders are actuated by 4-way solenoid controlled valves, all pilot operated. Electrical and hydraulic circuits are interlocked, and the feed channels are physically bolted together.

Flip-over mechanism for this line is simply a pair of heavy fingers spring-loaded to stand vertically, *Fig.* 4. At station 15 these fingers are in a horizontal position, lying flat on the runway. While in this horizontal position they grip the part, then advance toward station 16. Halfway between these stations there is a gap in the runway which permits the springs to rotate the fingers 90 degrees to a vertical position. As the fingers continue to advance, they are tripped another 90 degrees to complete the 180 degree turnover. On the return stroke the motions are reversed and the fingers are ready for another part.

The feed devices are designed so that the section in front of the die area can be removed, leaving the area open for die changing. In the present die setup the dies can be moved into or out of the presses without removing sections of the feed mechanisms. Additional presses and feed units can be added to the line or present equipment can be rearranged. Also, the controls are such that each press may be operated individually and fed by hand from front or back.

## ▶ Cycle Control

Presses in this line all cycle at the rate of 3 seconds per stroke; the transfer feed mechanism requires slightly more than 4 seconds to cycle; and the stack feed push bar completes its operation in about 2½ seconds. These independent mechanical and hydraulic actions are electrically coordinated into a composite automatic cycle which requires 5 seconds, *Fig.* 5.

In brief, the transfer feed begins to clamp when the presses reach the 240 degree points of their cycles—the punches are then high enough to allow the fingers to enter the dies. When clamping is completed, the feed advances, and the fingers unclamp at the end of the advance. When the work is fully unclamped and the fingers are completely out of the dies, the presses, which have previously stopped at top stroke, start another cycle and the feed channels return to home position.

Operation must be started with all devices in their home positions. The presses must all be at top stroke; the stack feed push bar must be withdrawn; and the transfer feed fingers must be unclamped and returned. If previous automatic operation was halted with the *Automatic Stop* button, all equipment will be in the home positions. Hydraulic pressures, lubrication oil pressures and air pressures to the clutches, brakes, counterbalance cylinders, and cushions must also be up to par before the control circuits will operate, and selector switches on the four presses must be set to automatic operation.

When the *Run* button on the lead press is hit, the solenoid actuated hydraulic clamp valve, SV-20

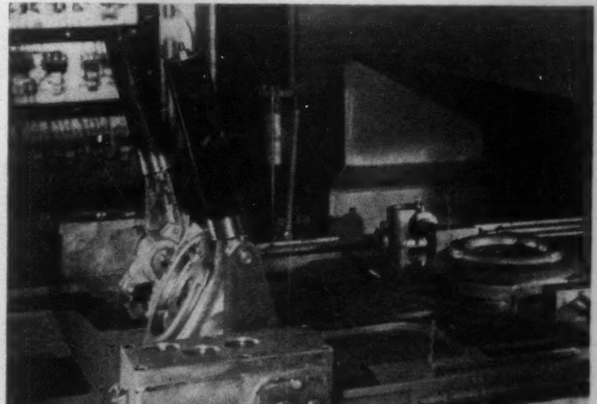

Fig. 4—As presently tooled for automobile wheels, the workpieces are turned over by this simple mechanical flip-over device at station 15.

in *Fig. 2*, will be energized. This will reverse the hydraulic circuits to the clamp cylinder, the piston will stroke, and the feed fingers will be moved inward to clamp. When the clamp piston reaches the end of its travel, it trips a limit switch, LS-23, which energizes the feed advance valve, SV-21, and the push rod advance valve, SV-12. This strokes their respective cylinders and both the feed channels and push rod travel forward. When the push rod reaches its forward position, it trips a limit switch, LS-16, which de-energizes its own solenoid valve, SV-12, and the rod moves back. When it again reaches home position, it trips a limit switch, LS-14, which must be closed to permit the transfer feed to start another clamping action.

Meanwhile, when the feed and advance cylinder has completed its stroke, it trips a switch, LS-22, which de-energizes the clamp solenoid valve, SV-20, and the unclamping action begins. When this action is complete, a switch, LS-21, is tripped which engages the four press clutches simultaneously, and a stroke is begun. This switch also de-energizes the feed advance solenoid valve, SV-21, initiating the return stroke. When the feed completes its return stroke, it trips another switch, LS-20, which must be closed to permit another clamp action. When the presses have all reached the 240 degree point of their cycles, their rotary cam limit switches close a circuit in series with LS-14 and LS-20. The clamp solenoid valve, SV-20, is energized, and the sequence is repeated. The presses complete a cycle while the feeds are still advancing, and they stop at top stroke to wait for the advance and unclamping actions to be completed.

A safety timer is provided in the automatic circuit. In the event that any action in the sequence is delayed more than 15 seconds, all automatic circuits will be broken. Such protection prevents an unexpected resumption of operation if the delay was due to a faulty valve or a cylinder even though it eventually crept to its limit switch.

Each press may be individually inched without running the feed. Clamping and unclamping actions of each of the three sections of the transfer feed may also be individually inched from the control panel of the respective press. All may be inched together from the panel of the lead press, and the advance and return motions may also be inched from this panel. The inching hydraulic circuit is identical with the running circuit, except that the flow of fluid is restricted to provide more sensitive control—note valves SV-23 and SV-22 in *Fig. 2*.

## ▶ Press Details

Each of the presses is equipped with a 50-ton self-contained pneumatic die cushion. Limit switches in the installation stop the equipment if a cushion fails to rise fully. Spring strippers are built into the upper dies to regularly perform the stripping function. All of the presses are also equipped with positive cam knockouts on their slides as a reserve safety measure to avoid picking up a piece part and creating an overload on the following stroke.

Clutch and brake units on the presses are Torna-

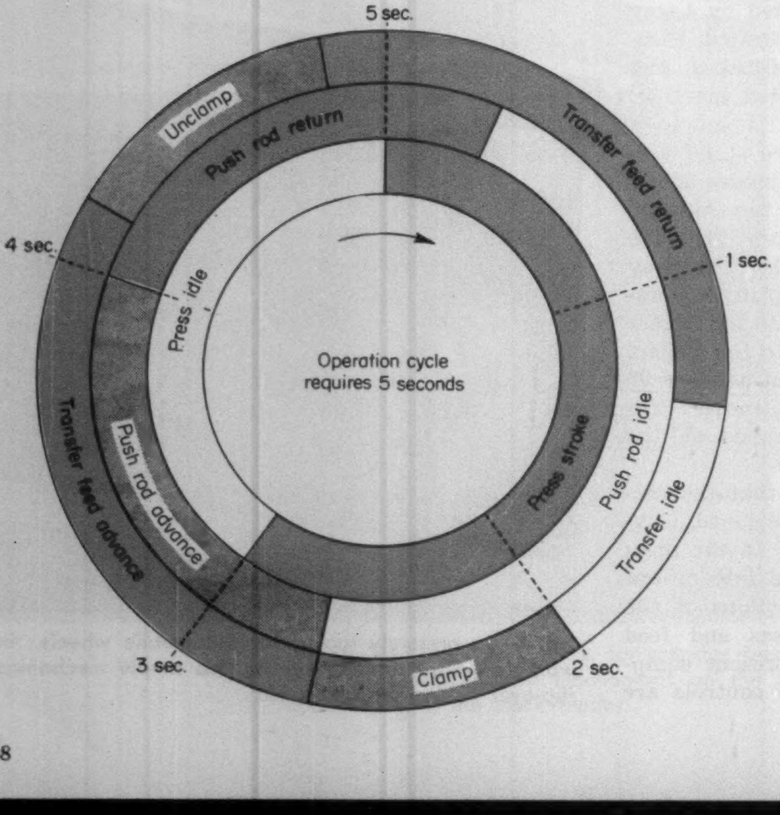

Fig. 5—When the line is operating automatically, the feeding actions are interlocked with the cycling of the presses. Feed motions are actuated when the rotary cam limit switches on the presses are tripped at their 240 degree points. The intermittent cycles of the presses are initiated in preset relation to the feed motions.

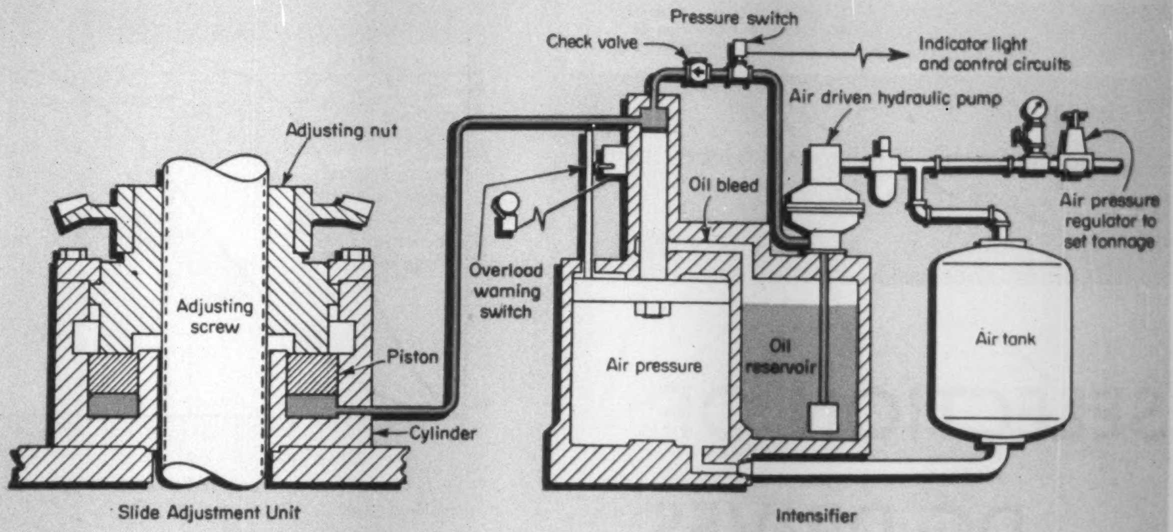

**Fig. 6—Of special value in an automatic operation is this system to prevent building up of pressure beyond an adjustable preset limit during the last ½-inch of press stroke. Press cycle during an overload continues to top stroke where the clutch is automatically disengaged.**

dyne units designed for low inertia losses and easy maintenance. Electrically operated valves control the air pressure which engages the clutch and releases the brake. When the air pressure is released, springs disengage the clutch and apply the brake. Lubrication of the unit—including flywheel bearings—can be entirely automatic. Friction inserts in the clutch and brake can be replaced easily, and adjustment for partial wear is readily made. The extent of lining wear is externally indicated by gage pins.

Hydraulic overload protection devices are installed on the three 600-ton presses. Such a device, sketched in *Fig.* 6, prevents a press from building up tonnage beyond a preset pressure in the last ½-inch of stroke. The slide may be prevented from bottoming, but the drive will continue through bottom, and sticking of the press will be avoided. The overload device provides a cushion of hydraulic fluid in a cylinder beneath the slide adjustment mechanism on the ram. Oil in this cylinder can only escape to the intensifier unit. When slide pressure is great enough, it will force down the piston in the intensifier, and the slide unit will compress as much as ½-inch. The tonnage at which the slide unit will compress is preset by adjusting the air pressure in the intensifier. In most applications they are set to relieve at 30 per cent overload.

In operation, an overload less than the relief setting will compress the slide unit and force the intensifier piston down far enough to trip the overload warning switch, and a warning bell will ring. If the overload compresses the slide unit 0.10 inch or more, the intensifier piston will be forced to the bottom of its stroke, and oil in the pressure circuit will bleed into the reservoir. If oil bleeds to the reservoir, then pressure in the pressure circuit will drop when the press begins its up stroke. This will trip the pressure switch, disconnect the operating button and slide adjustment control circuits, and light the red indicator on the control panel in place of the green light. The air driven hydraulic pump will immediately begin to replace the oil. When the oil pressure reaches normal, the pressure switch will close, the press will be ready to operate, and the green light will be energized in place of the red. The clutch is automatically disengaged at top stroke as long as the pressure switch is open. Electrical circuits are arranged to provide overload protection on inching as well as running cycles.

This press line has been erected and operated at the Clearing plant in Chicago before shipment to Dunlop, and performance has thus been checked before erection in the customer's plant. The features of this line and the advantages they offer illustrate the results possible when automatic methods are applied.

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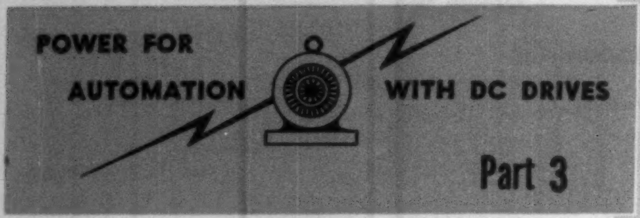
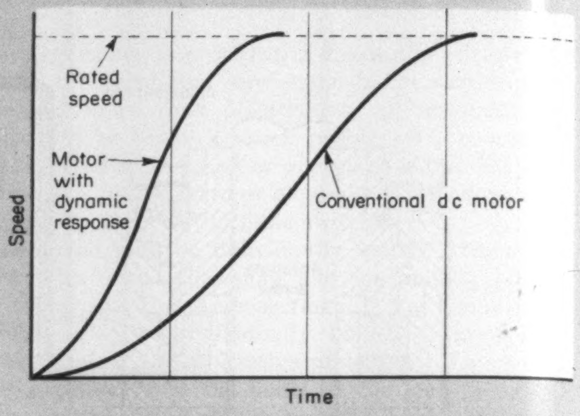


# SELECTION OF DC DRIVES AND CONTROLS



Comparison of Ability to Accelerate

**In this last article of the series, the author discusses the suitability of some available motor drives and controls to application in automation systems. Also included are selection guides for automation engineers needing controlled power.**

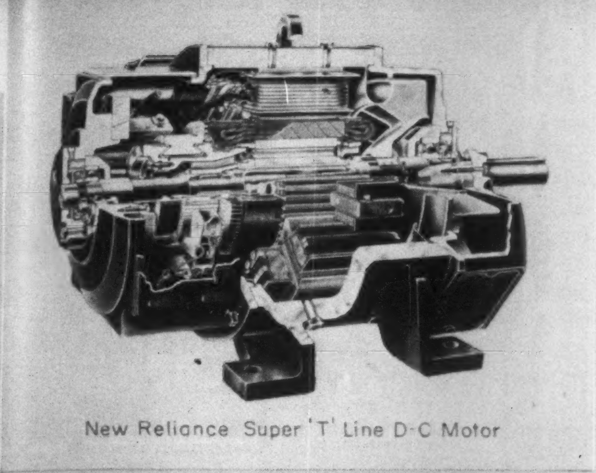
TWO BASIC and obvious requirements for systems and components that are to be used successfully in automating industry are: First, a high degree of performance must be built into the equipment because it must operate without the close manual supervision that has characterized most processes in the past; and second, exceptional reliability and ease of repair are essential because it is utterly impractical to have standby or alternate equipment to absorb the load of an automated line which is down for repair. Beyond these major concerns, space is an important factor; and appearance will grow in importance where pushbuttons and automatic operation have been introduced.

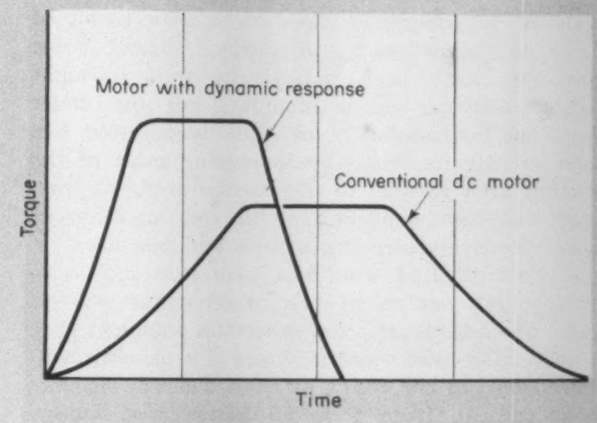
We can well afford, then, to spend some time in reviewing the developments of the last few years which have been inspired by the kind of thinking that resulted in the overall science of automation. Let us look first at the rotating power equipment—motors and motor-generators—which are the muscles of the system.

Traditionally this equipment has been designed as a source of rotating power delivered at the shaft which ran largely for long periods of time at a single speed, even though dc motors were expected to change speed from time to time. All design objectives therefore were concerned with producing a motor which would not have to start and stop frequently, but which would run reliably for long periods at full load. Economics on one hand were balanced against these necessary objectives on the other.

Over the past several years this thinking has changed. In redesigning the complete line of dc motors, Reliance has postulated that dynamic response is of importance equivalent to the ruggedness and reliability we have come to accept as standard. This has called for the inclusion of many important features in the new Reliance Super T motor.

Most fundamental is the principle that in a high performance system, motor and control are one. Even within the restrictions of a fixed overall design, considerable flexibility can be and must be allowed to permit integrating the motor into the complete system. For instance, in conventional operation it is usually entirely satisfactory to operate on 230 or 240 volts. In a high response system it is often desirable to select a higher





Comparison of Available Torque

Fig. 1—Comparisons of ability to accelerate and of available torque—Reliance Super T Motor versus conventional motor. The dynamic response is a direct result of lower electrical and mechanical inertia, higher commutating ability, and balanced design.

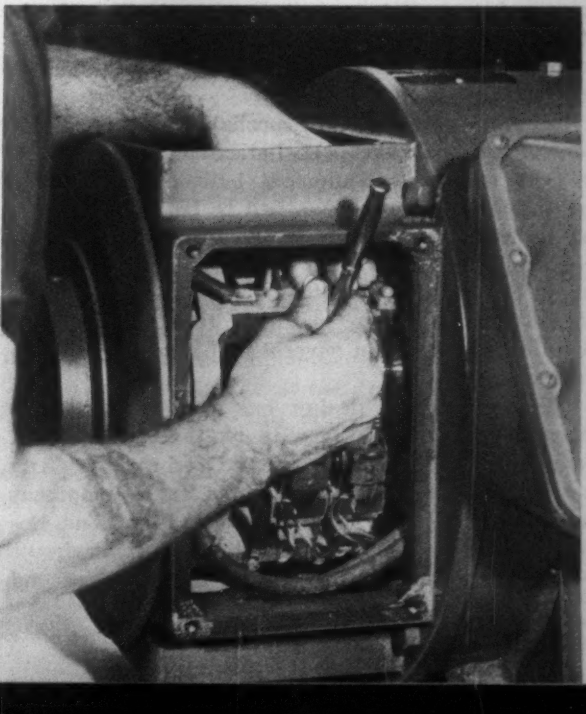
voltage and to build motor and generator for the higher values. Motors may be selected on the basis of their resistance or time constants rather than purely on the basis of horsepower and speed. There are many examples, but the point is all the same. For finest system operation motor selection must be made as carefully as the control, and motor parameters must be optimized for dynamic response.

Torque, inertia, and time constants are the motor parameters most affecting response. In general, across the board, maximum torque has been increased 50 per cent; inertias and time constants reduced 50 per cent, *Fig.* 1.

Torque involves several things. Mechanically, transmission of high torque calls for special attention to shafts, bearings, feet, locking of armature to shaft, and overall rigidity. Allowance for inclusion of roller bearings in larger motors has become a must. Electrically, high torque is somewhat more complex. To a motor, torque is current and magnetic flux. Commutator and brush structure concepts have had to be changed to pass the high currents. Commutator tolerances are more closely held. An insulating rocker is used, permitting the use of a rigidly located square stud against which the brush-holder seats firmly. Brushes are close to the stud with the spring mechanism overhanging—exactly the reverse of conventional practice, *Fig.* 2. All of these changes are essential if the motor is to produce maximum torque. Magnetically, field strengths were changed; interpoles were strengthened, frames thickened to give not only high flux capacity but to allow the high rate of rise needed in dynamic response systems.

Inertia involves reduction of diameter relative to length and reduction of overall mass regardless of distribution. Inertia concerns principally the rotating element and yet affects other things. In achieving small armature diameters the frame is similarly reduced, forcing the field coils to fit in the smaller space. As a result, field coils must be held to extremely close dimensional tolerance, and must efficiently conduct heat out of the machine center. In decreasing armature diameter, commutation problems are accordingly increased, requiring a much greater improvement in motor commutation than would normally be indicated. Reduction of armature diameter and mass necessitates effective cooling, and therefore through-ventilation inside the armature and commutator has been designed into the equipment. Armature time constants have been reduced by decreasing

Fig. 2—Covers removed at the commutator end of the Super T Motor to show assembly of rocker arm and brush rigging and accessibility for inspection and maintenance.



the number of inductive turns in this part of the motor.

Other improvements have come as a result of these and other design objectives. Overall motor diameters have been reduced by four to eight inches, allowing easier mounting on and under machines. Accessibility of the commutator has been greatly increased by increasing most of the bracket area parallel to the commutator. Appearance has been considered with the intention of more effectively blending motors and machines.

A great deal of what has been said applies to the back-up equipment (motor-generator set) as well. The additional point deserving emphasis here is that, after performance, space is a primary consideration. In the range of sizes wherein space is most critical, from 1 to 75 horsepower, motor-generator sets such as VS power units, are built in compact two-bearing type of construction in a surprisingly small space. In the range of 30 to 100 horsepower even greater savings in space can be made where use of an electronic back-up source, such as the Reliance Xatron VS Drive, is indicated, *Fig.* 3. Comparison of control unit size and space requirements of conventional motor-generator set, two-bearing set, and Xatron is shown in *Fig.* 4. This illustrates what advances can be made when the objective is defined and attacked.

In the area of control a great deal has been done, not just to get theoretical breadboard performance, but to achieve rugged industrial design. Relays have come under careful surveillance. Special contact materials have been developed for low power, high precision situations. Life cycles have been carefully studied and increased. Since many processes require a number of operations beyond the present reasonable capacity of industrial relays, long life telephone relays have been adopted for industrial use, necessitating the solution of such problems as protection from harmful plant atmosphere and isolation from vibration. Panel wiring is being laid in channels rather than as a cable or flat against the panel. This facilitates repair, makes changes simple when equipment is moved around and gives a very good appearance.

In the electronic field probably the most intensive studies have been indicated. The problem is easy to state. Equipment built principally for communications work has had to be made reliable by industrial standards under industrial working conditions. The problem has encompassed nearly all electronic components—tubes, resistors, potentiometers, capacitors, rectifiers, tube sockets. The solution has come in several steps worthy of fast review.

First, electronic design has had to allow for normal plant variations in voltage, frequency, temperatures, atmosphere, and vibration. Any circuit combination must remain in development until it is no longer critical in these directions. Because this requirement prohibits the casual circuit work often found in electronic design, a second and keystone practice has been brought about. Electronic panels must be designed for universal application, not job-by-job, but as standard building blocks to be put together to produce desired results. This is the only way to attain enough experience with given equipment to make it extremely reliable at an economical cost, *Fig.* 5. Despite all that is known, it is true in this field as in many others that the ultimate in reliability will not be achieved until field experience is gained.

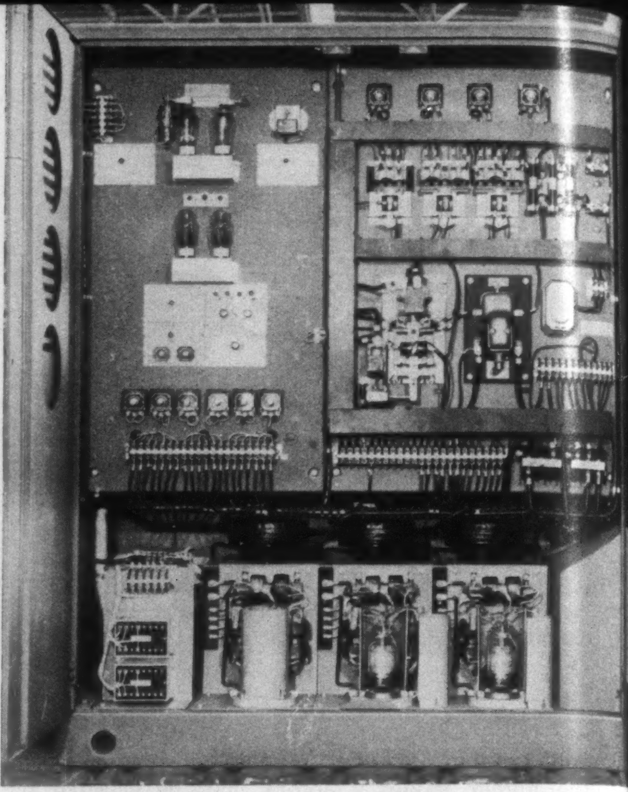
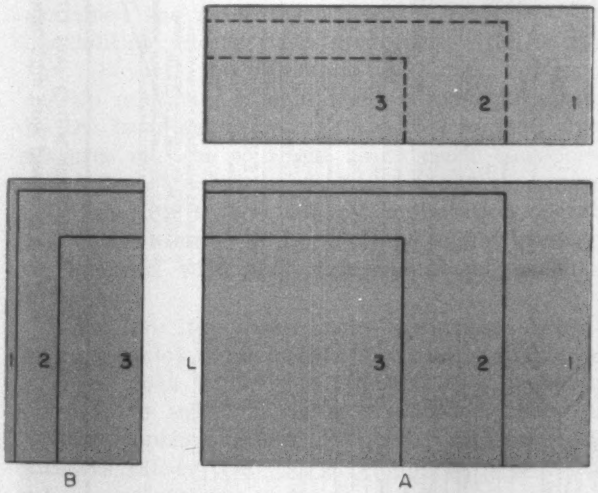


Fig. 3—Reliance VS Xatron Drive Control Unit—75 horsepower. Six Xatron mercury-arc rectifier tubes in a bridge circuit produce dc for the drive motor from power line ac. The drive is available in the range from 30 to 100 horsepower.

A recent development is the Reliance Sealpak Unit which embeds electronic components in an epoxy resin to minimize their vulnerability to the common industrial conditions. This process has achieved several outstanding results. It has refined the building block approach, insuring maximum experience since most Sealpaks are common to several regulator panels. It has completely enclosed the more delicate components in a solid mass whose insulating and heat conducting capacities are superior to still air. The resin excludes foreign matter eliminating creepage and corrosion, maintains spacings as they existed when the unit was made, and protects completely against normal vibration. Further, it has permitted the use of miniature tubes which are more highly developed than conventional octal base tubes. In open air, the spacing of the miniature tube socket pins is not sufficient to allow use in oily, dirty atmospheres. Embedded, however, the spacing is altogether adequate, and these superior tubes can be used. Screw connections in place of solder are provided for all external Sealpak connections.

In addition to these points, servicing, where necessary, is greatly simplified. The individual Sealpak units are not a miscellaneous assortment of parts but are logical circuit subdivisions. It has been possible, therefore, to group the parts on the wiring diagrams so that they not only fit intelligently into the schematic drawing but are also physically placed together, *Fig.* 6. Additionally and more important, complete test instructions are on the diagrams showing exactly what measurements should be read at each external terminal. If a failure occurs, the defective Sealpak can be removed and replaced with a new one in a matter of minutes. The cost of the units is low, and the approach is based upon the philosophy that expensive machines cannot be down, interrupting valuable production, while high cost maintenance personnel look over the equipment for one tiny troublesome component. This philosophy is a necessary adjunct to the advance of automatic techniques.

A great deal more could be said about the way this kind of equipment is and should be built. But the real point has been to emphasize by detailed example that a proper system is composed of elements which were designed for use in such systems. Poor performance will result if there is a weak link. Both motors and controls are important, and motor importance needs particular attention because it has been traditional to consider a motor as just a source of power. It has become a dynamic element.



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|---|---|---|---|
| 3 | $55\frac{7}{8}$ | $24\frac{1}{4}$ | $65\frac{3}{4}$ |
| 2 | $83\frac{3}{4}$ | 36 | 80 |
| 1 | 108 | 40 | $82\frac{1}{4}$ |

Fig. 4—Size comparison in three views between 75-horsepower drive control units with (1) four-bearing construction M/G set, (2) two-bearing M/G set, and (3) Xatron electronic rectifier.

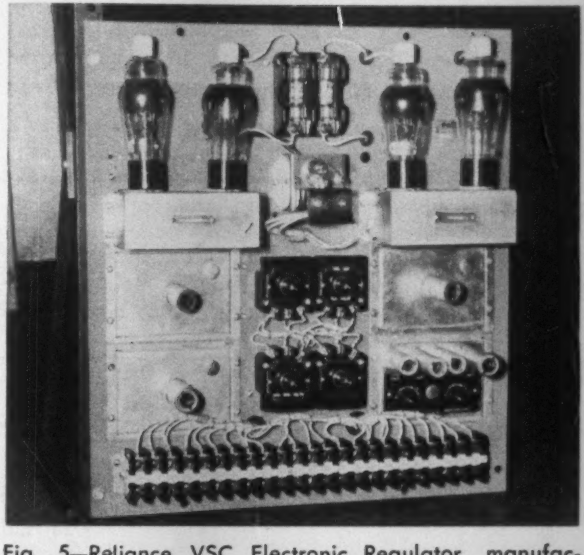


Fig. 5—Reliance VSC Electronic Regulator, manufactured at the rate of 75-exact duplicates per month, controls acceleration and deceleration of variable speed drives on production machinery.

## ▶ Selection Guideposts

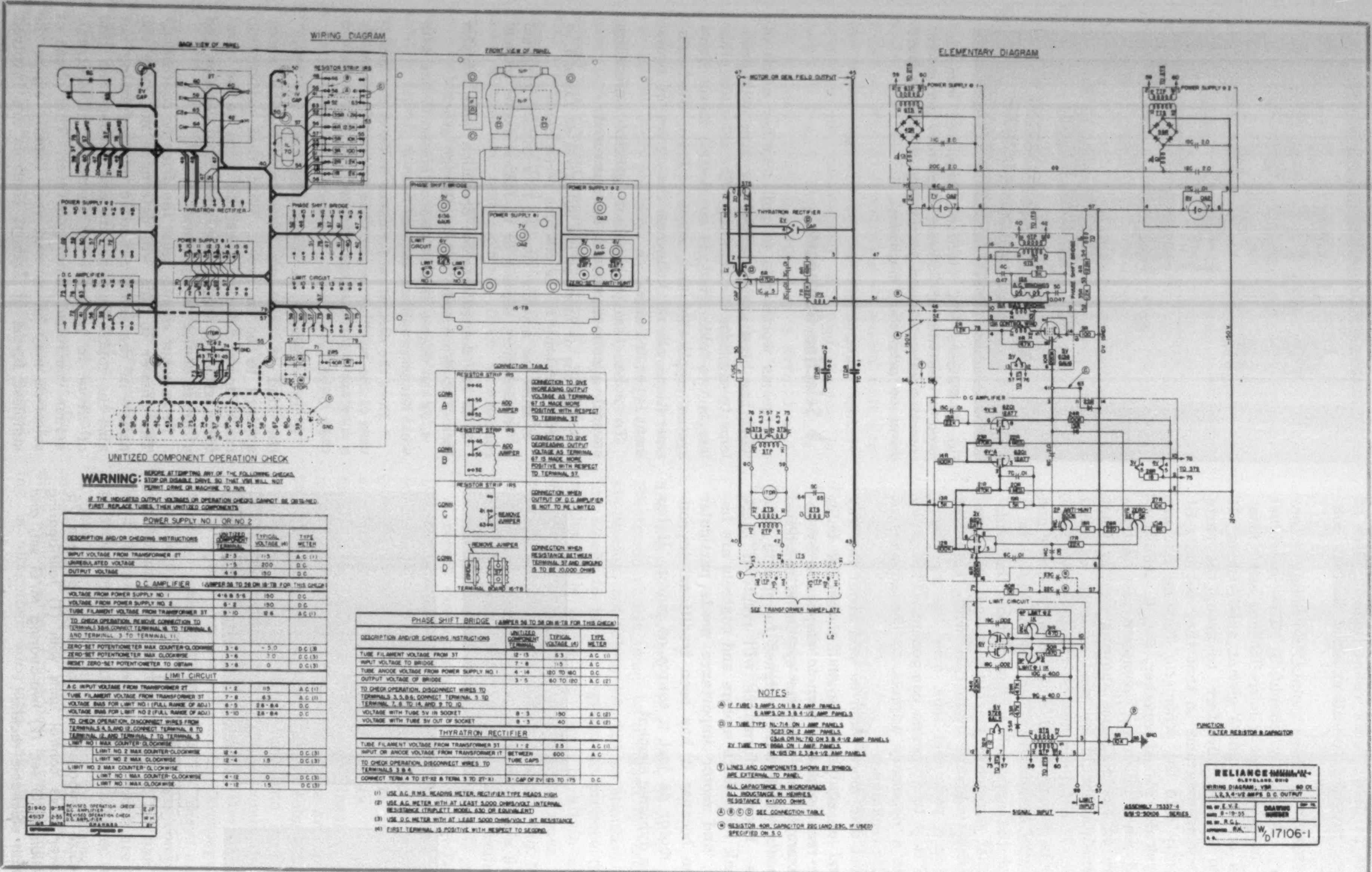
It seems worthwhile to pull together much of what has been said to assist the man with problems to organize his thinking. The selection problem is two-fold. First, is an electric motor drive system applicable and, second, if so, what considerations should influence the choice of equipment types and sizes?

To solve the problem of general suitability several questions should be answered:

1. Are one or more of the objectives of TABLE 1 of Part 2 necessary to the machine performance?
2. Must the machine respond to automatic program or measurement signals or to instantaneous manual control?
3. Is the desired machine operation more complex than *Stop-Start* and *Shift* or *Change gears?*
4. Is the degree of performance needed in line with what has been outlined earlier?
5. Does the desired performance increase the usefulness of the machine or machines sufficiently to justify a substantial increase over the cost of a simple squirrel cage motor?

If the answers to these questions are "Yes", the kind of drive we have been talking about appears to be in order. With that assumption made, more detailed questions need to be carefully settled to insure intelligent final decision and ultimate choice of equipment.

*From what signals must the drive be controlled?* The answer to this will determine not only the nature of the instrumentation or programing but also the controlling exciters and perhaps the kind of drive in general—for instance, all-electronic versus controlled motor-generator. This phase of selection may be covered very rapidly where the simplest forms of manual controls are involved.



UNITIZED COMPONENT OPERATION CHECK

**WARNING:** BEFORE ATTEMPTING ANY OF THE FOLLOWING CHECKS, STOP OR DISABLE DRIVE SO THAT VSR WILL NOT PERMIT DRIVE OR MACHINE TO RUN.

IF THE INDICATED OUTPUT VOLTAGES OR OPERATION CHECKS CANNOT BE OBTAINED, FIRST REPLACE TUBES, THEN UNITIZED COMPONENTS.

| POWER SUPPLY NO 1 OR NO 2 | | | |
|---|---|---|---|
| DESCRIPTION AND/OR CHECKING INSTRUCTIONS | UNITIZED COMPONENT TERMINAL | TYPICAL VOLTAGE (4) | TYPE METER |
| INPUT VOLTAGE FROM TRANSFORMER 2T | 2-3 | 115 | A.C. (1) |
| UNREGULATED VOLTAGE | 1-5 | 200 | D.C. |
| OUTPUT VOLTAGE | 4-6 | 150 | D.C. |
| D.C. AMPLIFIER (JUMPER 56 TO 58 ON 16-TB FOR THIS CHECK) | | | |
| VOLTAGE FROM POWER SUPPLY NO 1 | 4-6 & 5-6 | 150 | D.C. |
| VOLTAGE FROM POWER SUPPLY NO. 2 | 6-2 | 150 | D.C. |
| TUBE FILAMENT VOLTAGE FROM TRANSFORMER 3T | 9-10 | 12.6 | A.C. (1) |
| TO CHECK OPERATION, REMOVE CONNECTION TO TERMINALS 3&16, CONNECT TERMINAL 16 TO TERMINAL 6, AND TERMINAL 3 TO TERMINAL 11. | | | |
| ZERO-SET POTENTIOMETER MAX COUNTER-CLOCKWISE | 3-6 | -5.0 | D.C. (3) |
| ZERO-SET POTENTIOMETER MAX CLOCKWISE | 3-6 | 7.0 | D.C. (3) |
| RESET ZERO-SET POTENTIOMETER TO OBTAIN | 3-6 | 0 | D.C. (3) |
| LIMIT CIRCUIT | | | |
| A.C. INPUT VOLTAGE FROM TRANSFORMER 2T | 1-2 | 115 | A.C. (1) |
| TUBE FILAMENT VOLTAGE FROM TRANSFORMER 3T | 7-8 | 6.3 | A.C. (1) |
| VOLTAGE BIAS FOR LIMIT NO 1 (FULL RANGE OF ADJ.) | 6-5 | 2.6-8.4 | D.C. |
| VOLTAGE BIAS FOR LIMIT NO 2 (FULL RANGE OF ADJ.) | 5-10 | 2.6-8.4 | D.C. |
| TO CHECK OPERATION, DISCONNECT WIRES FROM TERMINALS 4, 5, AND 12, CONNECT TERMINAL 6 TO TERMINAL 12, AND TERMINAL 7 TO TERMINAL 5 | | | |
| LIMIT NO 1 MAX COUNTER-CLOCKWISE | | | |
| LIMIT NO 2 MAX COUNTER-CLOCKWISE | 12-4 | 0 | D.C. (3) |
| LIMIT NO 2 MAX CLOCKWISE | 12-4 | 15 | D.C. (3) |
| LIMIT NO 2 MAX COUNTER-CLOCKWISE | | | |
| LIMIT NO 1 MAX COUNTER-CLOCKWISE | 4-12 | 0 | D.C. (3) |
| LIMIT NO 1 MAX CLOCKWISE | 4-12 | 15 | D.C. (3) |

| | | | |
|---|---|---|---|
| 31940 | 9-56 | REVISED OPERATION CHECK D.C. AMPLIFIER | E.J.P. |
| 49137 | 2-55 | REVISED OPERATION CHECK D.C. AMPLIFIER | W.H. |
| S.O. | DATE | CHANGES | BY |

CONNECTION TABLE

| | | |
|---|---|---|
| CONN. A | RESISTOR STRIP 1RS<br>46<br>56<br>58<br>ADD JUMPER | CONNECTION TO GIVE INCREASING OUTPUT VOLTAGE AS TERMINAL 67 IS MADE MORE POSITIVE WITH RESPECT TO TERMINAL 57 |
| CONN. B | RESISTOR STRIP 1RS<br>46<br>56<br>58<br>ADD JUMPER | CONNECTION TO GIVE DECREASING OUTPUT VOLTAGE AS TERMINAL 67 IS MADE MORE POSITIVE WITH RESPECT TO TERMINAL 57. |
| CONN. C | RESISTOR STRIP 1RS<br>61<br>63<br>REMOVE JUMPER | CONNECTION WHEN OUTPUT OF D.C. AMPLIFIER IS NOT TO BE LIMITED |
| CONN. D | REMOVE JUMPER<br>GND<br>57<br>TERMINAL BOARD 16-TB | CONNECTION WHEN RESISTANCE BETWEEN TERMINAL 57 AND GROUND IS TO BE 10,000 OHMS |

| PHASE SHIFT BRIDGE (JUMPER 56 TO 58 ON 16-TB FOR THIS CHECK) | | | |
|---|---|---|---|
| DESCRIPTION AND/OR CHECKING INSTRUCTIONS | UNITIZED COMPONENT TERMINAL | TYPICAL VOLTAGE (4) | TYPE METER |
| TUBE FILAMENT VOLTAGE FROM 3T | 12-13 | 6.3 | A.C. (1) |
| INPUT VOLTAGE TO BRIDGE | 7-8 | 115 | A.C. |
| TUBE ANODE VOLTAGE FROM POWER SUPPLY NO. 1 | 4-14 | 120 TO 160 | D.C. |
| OUTPUT VOLTAGE OF BRIDGE | 3-5 | 60 TO 120 | A.C. (2) |
| TO CHECK OPERATION, DISCONNECT WIRES TO TERMINALS 3, 5, & 6; CONNECT TERMINAL 5 TO TERMINAL 7, 6 TO 14, AND 9 TO 10 | | | |
| VOLTAGE WITH TUBE 5V IN SOCKET | 8-3 | 150 | A.C. (2) |
| VOLTAGE WITH TUBE 5V OUT OF SOCKET | 8-3 | 40 | A.C. (2) |
| THYRATRON RECTIFIER | | | |
| TUBE FILAMENT VOLTAGE FROM TRANSFORMER 3T | 1-2 | 2.5 | A.C. (1) |
| INPUT OR ANODE VOLTAGE FROM TRANSFORMER 1T | BETWEEN TUBE CAPS | 600 | A.C. |
| TO CHECK OPERATION, DISCONNECT WIRES TO TERMINALS 3 & 4. | | | |
| CONNECT TERM 4 TO 2T-X2 & TERM 3 TO 2T-X1 | 3-CAP OF 2V | 125 TO 175 | D.C. |

(1) USE A.C. R.M.S. READING METER, RECTIFIER TYPE READS HIGH.

(2) USE A.C. METER WITH AT LEAST 5,000 OHMS/VOLT INTERNAL RESISTANCE (TRIPLETT MODEL 630 OR EQUIVALENT)

(3) USE D.C. METER WITH AT LEAST 5000 OHMS/VOLT INT. RESISTANCE.

(4) FIRST TERMINAL IS POSITIVE WITH RESPECT TO SECOND.

NOTES:

1F FUSE: 3 AMPS ON 1 & 2 AMP PANELS
6 AMPS ON 3 & 4-1/2 AMP PANELS

1V TUBE TYPE: NL-714 ON 1 AMP PANELS
3C23 ON 2 AMP PANELS
C3J/A OR NL-710 ON 3 & 4-1/2 AMP PANELS
2V TUBE TYPE: 866A ON 1 AMP PANELS
NL-815 ON 2, 3, & 4-1/2 AMP PANELS

LINES AND COMPONENTS SHOWN BY SYMBOL ARE EXTERNAL TO PANEL.

ALL CAPACITANCE IN MICROFARADS
ALL INDUCTANCE IN HENRIES
RESISTANCE K=1,000 OHMS

Ⓐ Ⓑ Ⓒ Ⓓ SEE CONNECTION TABLE

RESISTOR 40R, CAPACITOR 22C (AND 23C, IF USED) SPECIFIED ON S.O.

FUNCTION
FILTER RESISTOR & CAPACITOR

ASSEMBLY 75337-4
[illegible] SERIES

RELIANCE ELECTRIC AND ENGINEERING CO.
CLEVELAND, OHIO
WIRING DIAGRAM, VSR 60 CY.
1, 2, 3, 4-1/2 AMPS D.C. OUTPUT
DR. BY E.V.Z.
DATE 8-19-55
CH. BY R.C.L.
APPROVED R.K.
S.O.
DRAWING NUMBER
W/D 17106-1

Fig. 6—Sealpak wiring and circuit diagrams and check table. Components of the circuit are grouped with maintenance and test in mind so that downtime can be minimized

or it may be the principal consideration from the standpoints of complexity, cost, and difficulty of finalizing. This would be true of systems involving advanced concepts of automation.

In a system which is to be highly automatic, spelling out the exact operating requirements must be done with at least three major factors kept in constant balance—desired function, first cost and cost saving, and maintenance. In general, optimum performance must be modified by cost considerations. This is as true in the new fields of industry as in buying a new car at home. There is the additional critical consideration that the limitation upon the practical degree of automating is seen more and more to be reliability or constancy of operation. This imposes upon the concerned personnel the obligations of specifying high quality in component construction and system design and of providing maintenance service of a high caliber. Whenever cost gets too high or the system looks too complex to operate, the functions specified must be readjusted to get these things in line. It is normally true that this can best be done by the user and equipment supplier jointly, with each contributing from his own specialized knowledge.

*What must the drive motor do?* When the controlling signals have been established, some of the duties of the motor will have been spelled out. Nevertheless, it is necessary to look carefully at the motor to tie down exactly what is expected of it. For instance, to follow the signals forced acceleration may be required, and the rate of response definitely established, or slow acceleration may be required. Linearity between input signal and output speed may be essential. Thus, when the overall control scheme has been set, the part of the system supplying the power must be examined and made to include the responses and capabilities necessary for integrating with the control. Beyond the fundamental things (often a certain minimum of equipment is made necessary by the basic requirements) the cost of additional features may be so slight as to merit consideration. Preset jogging, electrical braking, current over-limit for torque control, multistation operating control—any or all of these might possibly be included with the basic equipment at little extra cost.

*What are the horsepower (continuous, peak or duty cycle) requirements?* By taking advantage of high peak capacity equipment it is normally possible to select a motor size based upon the average continuous need obtained from duty cycle analysis rather than the maximum or near maximum requirement.

*For what speeds should the motors be built?* Economic balance between motor and transmission cost should be maintained. Where exceptional accelerating performance is needed, consideration should be given to modification of the machine gearing to suit the optimum motor for the job.

*What operating and indicating devices are required?* Location and layout of pushbuttons, switches, rheostats, motors, etc., is an important and often overlooked area for increasing machine efficiency. The number of situations is infinite, but some general rules apply:

1. Operating panel or console should be as near as practical to the critical part of the process, and should be easily reached from all normal operator positions.
2. Panel should be laid out for maximum convenience to the operator—hand, arm, and leg motions should be minimized.
3. Operating panel or console should be consistent with the machine in quality and appearance.
4. Meters should be provided to measure the results of adjustments and to permit observation of important machine conditions.

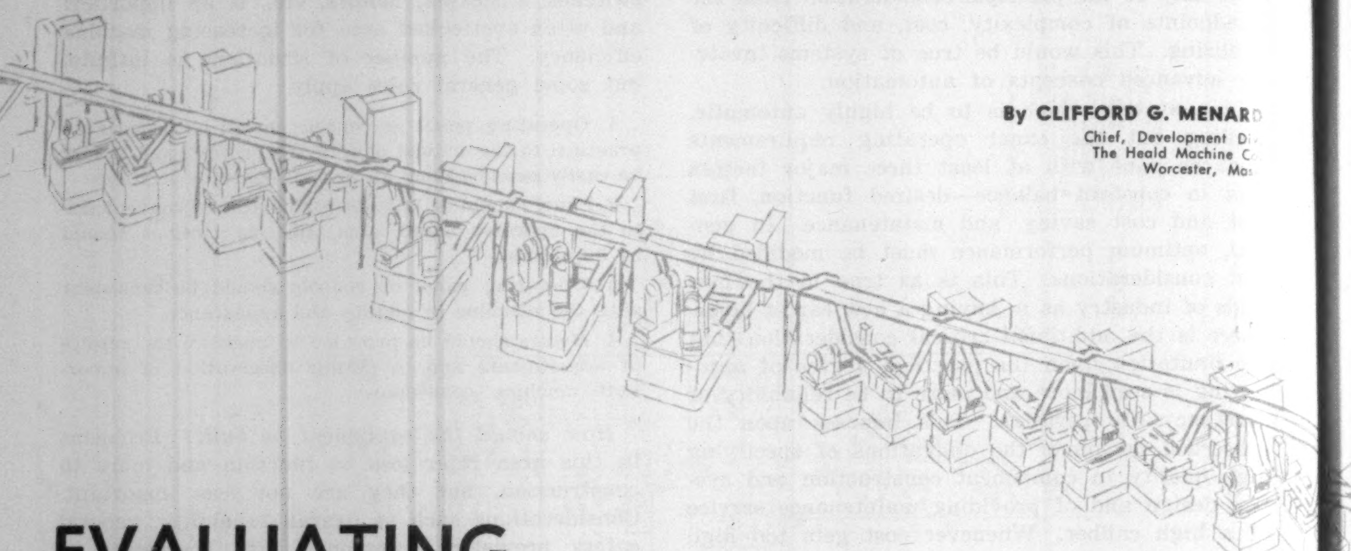
*How should the equipment be built?* Problems in this area refer less to function and more to construction, but they are not less important. Considerations such as overall reliability, general safety provisions, component life (pertinent to high cycling or continuous operation), conditions of atmosphere and temperature, enclosure of all equipment, and space consumed often determine how far we can go performance-wise.

The intention of these articles has been to show the relation of electric adjustable-speed drives to the field of automation. All machines require power, and electric drives are unsurpassed from the standpoints of flexibility, reliability, and low maintenance operation.

We have undertaken to point out some of the things that have been done in the recent past to show that the groundwork for the future has been carefully laid. Any machine system consists of system intelligence, the power control, and the power. VS Drive development at Reliance has been in the direction of producing control and power apparatus flexible enough to be subject to any control signal dictated by a given set of circumstances. Nearly all variables can be measured and transduced into control signals, so the work to be done in specific situations is merely to refine the elements involved to suit the particular application.

We have stated in some detail what the drive equipment will do beyond the obvious—both as to general function and more detailed performance. The increasing precision required of this kind of apparatus made necessary a look at its construction and design. It is apparent that characteristics which could in the past be neglected or ignored are coming into prominence. Unusual performance must be built into motors. Unusual reliability is the essential quality of modern control. In general, a proper system must be composed of units designed with the broad end in mind.

Finally, we have stated the questions which must be settled, first to decide if such equipment is applicable and, second, to arrive at a sound approach for evaluating cost or specifying for bid. All these things have been directed to the end of providing knowledge in usable form to add to the reader's kit of automation tools.



# EVALUATING MACHINE TOOL ARRANGEMENTS

## FOR AUTOMATED PRODUCTION

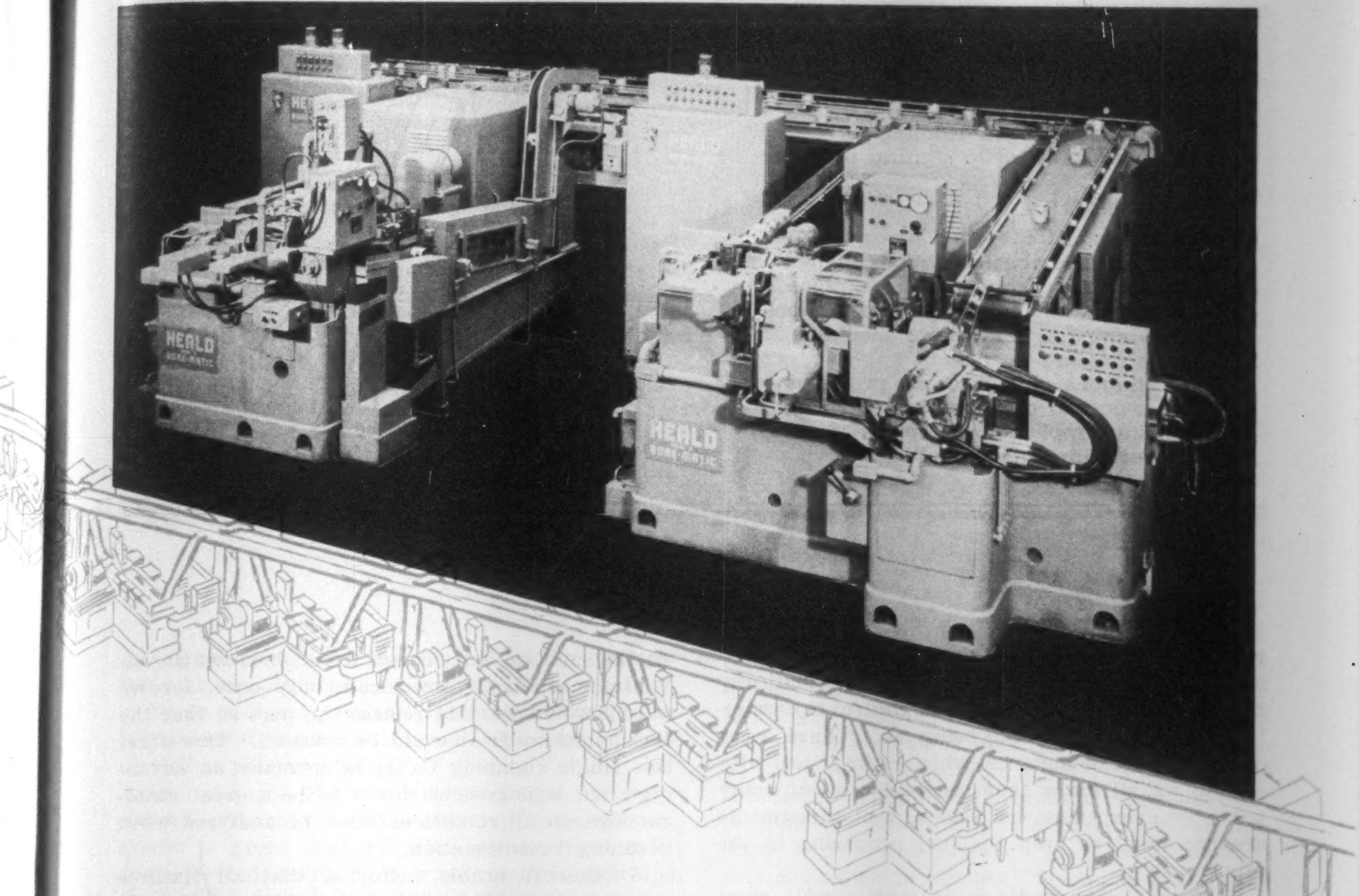
By CLIFFORD G. MENAR
Chief, Development Di
The Heald Machine C
Worcester, Ma

The author classifies machine tool automation into four principal types and analyzes each for favorable and unfavorable aspects. These observations are based on long and successful experience of the machine tool industry with automation.

MANUFACTURERS of machine tools are well prepared when industry calls upon them for automated setups. Their individual machines have been redesigned with a real knowledge of what has caused problems in the past. No matter what is required for an automated setup—a complete machine or only a sectional part of a machine—it is possible to design with an assurance that performance will be entirely adequate for whatever tolerances the machine tool builders set out to achieve.

Let us see what we should be on our toes about when we are considering an automated setup. Basic controls are very important. For instance, we must examine and decide upon either manual or automatic pregaging of the part, which is required to assure that the part going into the automated setup is in the proper condition to be machined. Usually pregaging consists of roughly checking the previous operations which have been performed to ascertain that the part about to enter the machine is in proper position, and that if it does get into the machine improperly, interlocks stop the machine and indicate where the problem exists. Possibly this could be eliminated when the part to be machined is a rough casting but in most cases pregaging of even rough castings is necessary, since the locating surfaces could have deformities, flash may be present due to a mold that hasn't closed completely, or cored holes may not be through due to a broken core. We must remember at all times that we are dealing with an expensive piece of equipment, that being down for tooling changes is enough unproductive time without adding the danger of smash-ups.

Fixturing as used on any machine tool should be thoroughly studied. We must think of many phases here, for when a part is put into a machine by an operator, he does many things without thinking such as seeing that the fixture is clean especially at the locating points. This means that on an automated setup the locating points must be flushed clean or air-blown clean automatically. When clamping is performed by an operator he



Two Heald Bore-Matics arranged for continuous high production boring of automotive pistons. Once operation is started, requirements of the operator are limited to occasional tool adjustments and replacement.

uses his judgment as to the amount of clamping force necessary, whereas with automation it must be done by automatic regulation. If an operator sets jacks under his work for support he again has the sense of feel which when automated must be done by design sense.

Another important step is to interlock the machine if the part is not properly located. This can usually be done by a switch operated by the part in its clamped position. Another thought we should keep in mind is that many parts are symmetrical in shape and would fit into the fixture two or more ways. If this is so, then a simple interference pin can usually be applied so that parts will assume only one position in the fixture.

Another point that is important is protection against tool breakage. Tools that are used for removal of large amounts of stock such as drills, hollow mills, etc., are the ones which are critical; it may be necessary to automatically check to be sure that an operation has been performed before passing the part into the next station.

Of course, either a chart that indicates when tooling changes should be made, or an electric counter set up for each station that automatically shuts down the line until the tooling is changed, are considered necessities in successfully operating automation setups. Another very important factor that should not be forgotten is the ability to change tools quickly. Preset tools are practically a must and they should be mounted in accurate, replaceable holders of the quick-change variety.

Removal of chips on automated setups may seem insignificant, but a great number of setups have scheduled downtime to clean up chips, and usually a great deal more than chip removal has to be done. With inadequate and poor chip disposal scored ways will be formed due to chips in the lubrication oils and many times chips will contaminate the hydraulic oil when there are open drain areas in the base. When coolant is necessary this adds to the chip disposal problem immensely.

Feedback systems to keep tools "on size" may be very helpful in getting more hours from an automated setup. This type of control is usually operated from an after-gage that measures the

**FAVORABLE**

- Floor space economy
- Single clamping & locating
- Fixtures returned to starting position

**LESS FAVORABLE**

- Balancing of operation times
- Size and number of stations limited
- Restricted approach to work piece
- Vibration influence between stations
- Tool changes idle entire machine
- Auto loading restrictions
- Continuous chip removal problems
- After-gaging and feedback limited
- Coolant application & splash welding
- Power clamping difficulties

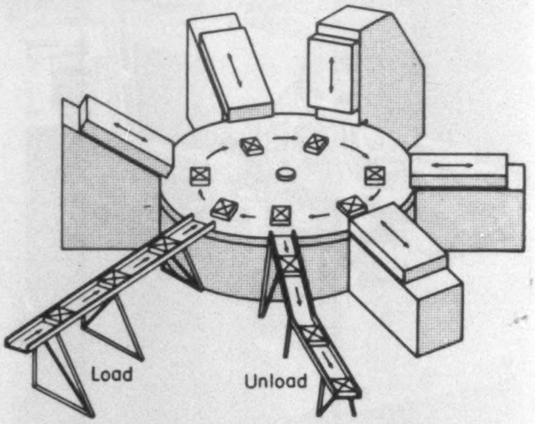


Fig. 1—Circular index automation.

part and then feeds the signal back to the machine where an adjustment will be automatically made for tool wear. This type of control is normally used when the material being cut produces wear on the tool. For instance, when cutting steel with a tool, we all know that the tool can cut many parts per sharpening, but several tool adjustments are necessary to keep the tool producing to the proper size.

This is where feedback is very useful since today both stationary or rotating tools can be made to accept signals and adjust for size. When after-gaging is used in an automated setup, it may be necessary to have a washing station between machining and gaging to remove chips from the part before measurements are taken. A rust inhibitor should be included in the wash formula as the part may not be assembled for many hours.

## Types of Automation Systems

If these basic fundamentals are kept in mind, our planning becomes a matter of choosing a type of automation dependent on the part design and its requirements.

Machine tool automation can be classified in these four principal types:

1. Circular index automation
2. In-line index automation
3. Constant travel automation
4. Unitized automation

Let's look at each one of these and analyze them. *Circular Index Automation*: In this type the workpiece is moved intermittently from one working station to another in a circular path, *Fig.* 1. One of the favorable factors in this system is floor space economy, another is the clamping and locating of the part only once. But if the part is a casting and we must rough it out, it is not an advantage to clamp and locate only once, for we surely would want to release the part so that the strains set up in it could be released. Therefore, this single clamping factor is normally an advantage, but it is possible for it to be a great disadvantage, so all conditions must be analyzed when planning for automation.

Another favorable factor is that all fixtures return to a starting point so that this type of automation lends itself to both manual and automatic loading of parts. A factor that might be considered less favorably is the time of the longest operation compared with other operations, since the time for the cycle is the longest operation plus the index time. This arrangement also has definite

**FAVORABLE**

- Work flow facilitated
- Number and type of stations flexible
- Opportunity for re-orienting part
- Approach to work less restricted
- Continuous chip removal practical
- Vibration effect negligible
- Simple auto loading facilitated
- Heat & distortion effect minimized

**LESS FAVORABLE**

- Balancing of operation times
- Repeated relocating and reclamping
- Tool changes idle many stations
- Increasing stations decreases efficiency
- After-gaging & feedback limitations
- Compromise between floor space & accessibility
- Awkward parts require pallets

**FAVORABLE**
Single clamping & locating
Identical simultaneous operations

**LESS FAVORABLE**
Type of operation restricted
Workpiece variety limited
Automatic gaging and feedback curtailed
Tool changes stop work flow
Auto loading "On the Fly"

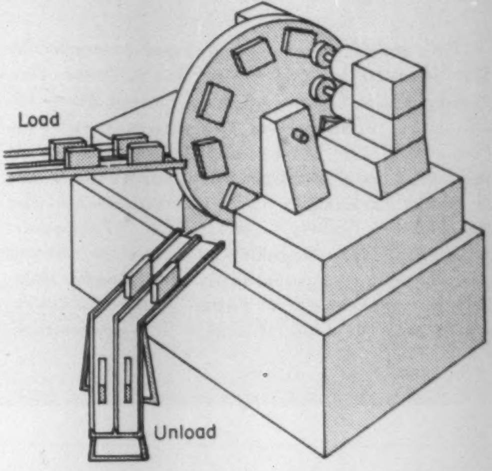


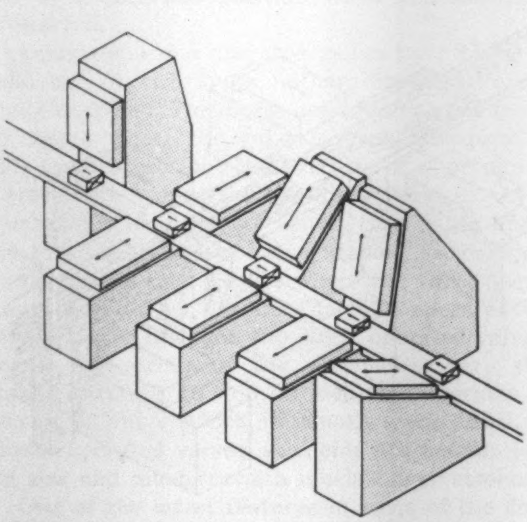
Fig. 3—Constant travel automation.

limitations since the number of stations is dependent on how large an indexing table is practical.

There is also a possibility that vibration may be a problem if there are intermittent roughing cuts as well as precision cuts.

Tool changes idle the entire machine, reducing overall efficiency. Continuous chip removal requires a great deal of planning as there is a very limited number of ways to remove chips from this type of machine. After-gaging and feedback are not generally used due to space limitations. Coolant application and splash shielding can be more difficult without the use of special manifolding. Usually in cases of this type, spring clamping can be utilized with power release at the unloading and loading stations; power clamping would be a real problem.

Fig. 2—In-line index automation.



*In-Line Index Automation*: This is a system of intermittently moving the work from one station to another in a straight line, commonly referred to as the transfer type, *Fig.* 2. It is often favored because it facilitates the general flow of work through the plant and comes closer to many concepts of flow automation. It permits considerable flexibility in planning the number and type of stations. Floor space and operating efficiency become the principal limiting factors but there is much more freedom allowed than on the rotary index machine. The part can be oriented or turned into different positions between stations. Continuous chip removal is relatively easy. The effect of vibration between stations is very slight due to the normal separation of stations.

The in-line transfer becomes a very simple problem with the use of hydraulic or air cylinders which can be interlocked electrically. Loading and unloading at each end of the line can be manual or automatic and is a simple conveyor problem. Distortion in parts is minimized due to successive clamping and the time interval between operations. A less favorable factor is the necessity to balance the production time between stations to arrive at a suitable cycle time. This frequently means that operations such as drilling of deep holes must be divided between stations. Tool changes idle many stations, reducing the operating efficiency. Sometimes this requires planning the machine in sections with independent transfer mechanisms and banking facilities between stations.

After-gaging and feedback may be limited since this is usually done at a separate station which delays the signal for the feedback correction so that an additional part may be machined without correction. Accessibility between stations must be provided for tool changes and machine servicing—which means more floor space. A very prac-

**This article is based on a paper presented by Mr. Menard at the Pennsylvania State University Short Course on Automation, June 10-15, 1956. Chairman of the program was Professor Chester Linsky of the department of industrial engineering and sponsors were the National Association of Manufacturers and the American Society of Tool Engineers. AUTOMATION Magazine was one of several co-operating organizations, with Roger Bolz, Editor, presenting a paper and conducting workshops on product design for automation.**

tical economy in floor space is to arrange the electrical control boxes and hydraulic power units on a catwalk above the transfer machines, but this requires the use of sump pumps in the hydraulic system to return drain lines to the main oil tanks. Another desirable factor is to have each station provided with independent pushbutton controls so that each individual station can be operated independently by the setup man.

*Constant Travel Automation*: This system has not been widely used in machine tool automation. In this arrangement the workpiece moves continuously within a straight line or a circular path and the tools rotate continuously, *Fig.* 3. In this system locating and clamping are done only once. It is possible to handle more than one part through the machine at one time, so that duplicate operations are done simultaneously. Less favorable factors are: Restrictions on the type of operations that can be performed; very limited variety of parts that can be handled; automatic gaging and feedback are curtailed. Work flow stops when tools are replaced and loading and unloading must be accomplished "on the fly."

*Unitized Automation*: This is the use of separate independent machine units automated through special work handling conveyors, chutes, elevators, and loading equipment, *Fig.* 4. First, this system provides continuous work flow as each operation can be performed on whatever number of units are required for the particular operation, with each unit working at its peak of efficiency. Use of separate machines makes for easier application of a variety of machine types, including standard models. If suitable units are already available, it may be possible to fit them into this system. Specialized units made by different manufacturers can be utilized and their peculiar advantages adapted to the system. In-process gaging, after-gaging, and feedback are applicable. Banking of parts is automatic allowing all units to function even though one unit may be down for tool change.

The overall operating efficiency on this type of setup probably would be the highest of the systems discussed. However less favorable factors exist, such as the difficulty in handling of awkward parts, floor space required is usually much more than the other systems, and there is duplication of equipment, especially orienting and gaging equipment. Another real factor in its favor is the flexibility in adding and removing operations, increasing production or accommodating part changes.

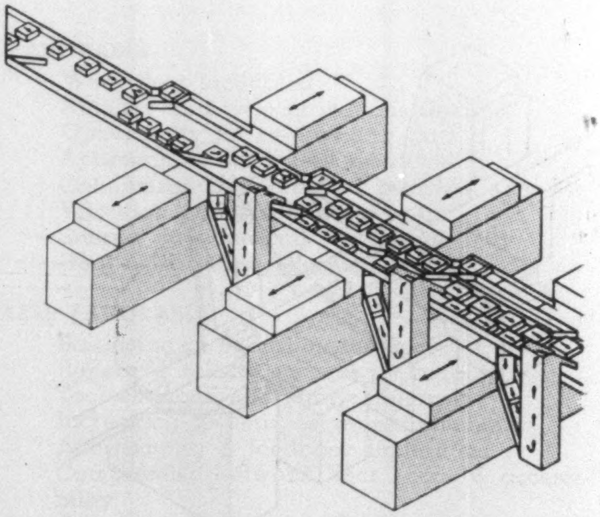
Fig. 4—Unitized automation.

**FAVORABLE**

Continuous work flow provided
Number of stations unlimited
Opportunity for re-orienting part
Approach to work unrestricted
Continuous chip removal made easy
No vibration effect between units
Complete freedom in auto loading
Existing machines may be adapted
Different mfrs units readily incorporated
After-gaging & feedback unlimited
Parts banking provided
Tool changes idle single unit
High overall operating efficiency
Efficient operation at different production rates
Adaptability to change
Economy in number of units

**LESS FAVORABLE**

Work piece size & design restricted
Floor space may be increased
Equipment elements duplicated



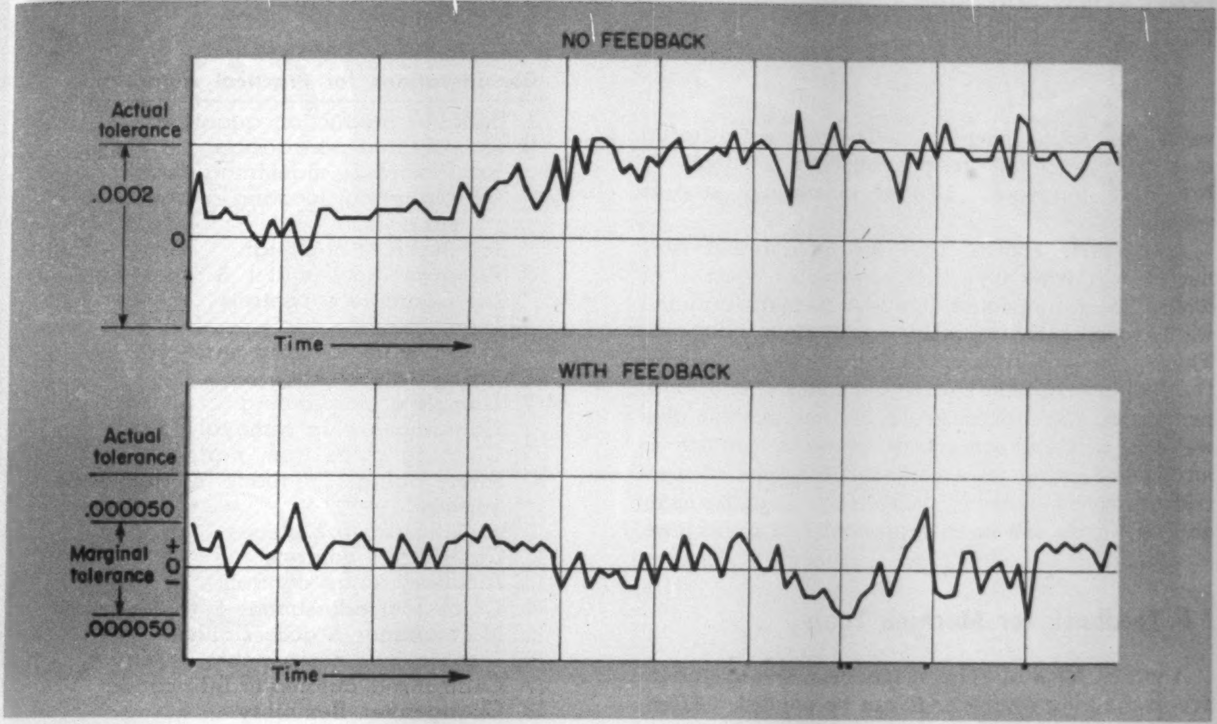


Fig. 5—Graphs of internal grinding operation with and without feedback. A feedback correction is indicated by marks along the time axis and occurs whenever a part is not within marginal tolerance. By making corrections in this manner, all parts are held within actual tolerance.

## Control Equipment

Let's describe some of the controls used in the various automated setups. As you all know, solenoid operated 4-way valves are used in great numbers. They should be chosen with great care as there are many types and there is a place for each type. A single solenoid operated with spring return is normally used for any operation where, in case of a power failure, a particular unit should be in a returned position when the machine is restarted.

Double solenoid operated valves have many uses and are of two types, either direct operated or pilot operated. The direct operated valve is normally found where the valve is used infrequently in the cycle operation; it has a life of approximately three million operations without service. A pilot operated solenoid valve usually has a life of from 20 to 25 million operations without servicing, and is usually used in a cycle where the valve operates several times per cycle. The pilot operated valve has a longer life than the direct operated valve because the stroke of the solenoid is very short, usually from 1/16 to 3/32 inch, and operates only the pilot valve which is usually very small. On direct operated valves, solenoids are usually larger in size and must travel a much longer stroke.

One of the latest features in some of the double solenoid valves has been the addition of friction in the main valve spool, so that only momentary contacts need be used to shift these valves. A balanced valve needs friction or power to hold it at its shifted position because there is a small end force developed from fluid flow which causes the valve to tend to shift its position. Since the force is small, only a small frictional force is required to keep the valve in position.

This improvement has a twofold advantage: First, the solenoids are powered only momentarily and consequently run cool; and secondly, extra contactors to maintain power to the solenoids are eliminated which is certainly a step in the right direction.

We should discuss valve mountings to some extent. Almost universally, machine tool manufacturers have gone to panel mounted valves on manifold plates. These are either drilled from solid plates or are of the sandwich type where a cored center plate is sandwiched between two solid plates. Either of these types of plates have performed satisfactorily and have been very instrumental in reducing the number of pipes required in the hydraulic system, as all interconnections between valves are either cored into or drilled into this plate, leaving only one pressure line into the plate and one return line from it. All other connections to the plate are usually to operate units incorporated into the automated setup.

We think that all stations of an automated machine should have an emergency stop valve, solenoid operated, and also a lever operated throttle valve for setup purposes. This allows a setup man to "creep up" to positions to set tools or for other purposes. Use of emergency stop is self-indicative.

An electric control that we have found very useful is a drum type that consists of a series of disks. Each individual disk is a 20-tooth cam and we have mounted as many as 52 disks in a row. This drum switch is driven by an electric motor through a magnetic clutch and indexes one tooth per index. By breaking out sections of this disk we can make a contact or break a contact at any index giving us a very flexible type of electric control of machine cycles. By changing cams any new cycle can be incorporated into a machine.

### Feedback for Machine Tools

Another form of control has been the use of in-process gaging wherever it can be applied. After-gaging is perhaps the most used type of gaging, as it fits into most types of operations.

Gaging systems most used are either air or electronic and are very reliable. Gates can be added to this type of gage that remove parts from the material flow line which are undersize or oversize. Also, feedback signals can be initiated. This latter feature has been one of the great advances which make automated lines more successful than ever.

One word of caution should be given, however. Do not try to correct every piece to nominal size, as every machine made today has what is known as noise level or scatter pattern as far as size holding ability. Let's assume we are boring a hole or turning a diameter. We find that we produce some plus parts and some minus parts from the mean size, but when we try to correct for these machine variations, we aggravate this condition of plus and minus.

Feedback signals should be initiated by measurements outside of the machine capability limits. In most operations there is machine drift as well as tool wear that causes size variation beyond inherent machine variability, and these are what feedback will correct. We haven't found a method to make old machines produce to new machine tolerances by any means, but we have found some answers on how to keep producing in-tolerance parts at a very low percentage of scrap on machinery that is capable of producing in-tolerance parts.

**TABLE 1**

**Considerations for Practical Automation**

1. Suitable production quantities
2. Coordinated part design
   (a) Favorable machining character
   (b) Orienting, locating & transferring surfaces
   (c) Stability of design
3. Adequate tool, cutter & wheel life
   (a) Counters & controls
4. Pre-inspection
5. Clean work locating surfaces
6. Safety interlocking
7. Complete foolproofing
8. Continuous chip removal
9. Clearing chips from part
10. After-gaging, feedback & automatic sorting
11. Banking of work pieces
12. Centralized controls
13. Auxiliary setup controls
14. Quick tool adjustment & replacement
15. Maintenance & accessibility
16. Trouble free components
17. Centralized automatic lubrication
18. Changeover flexibility

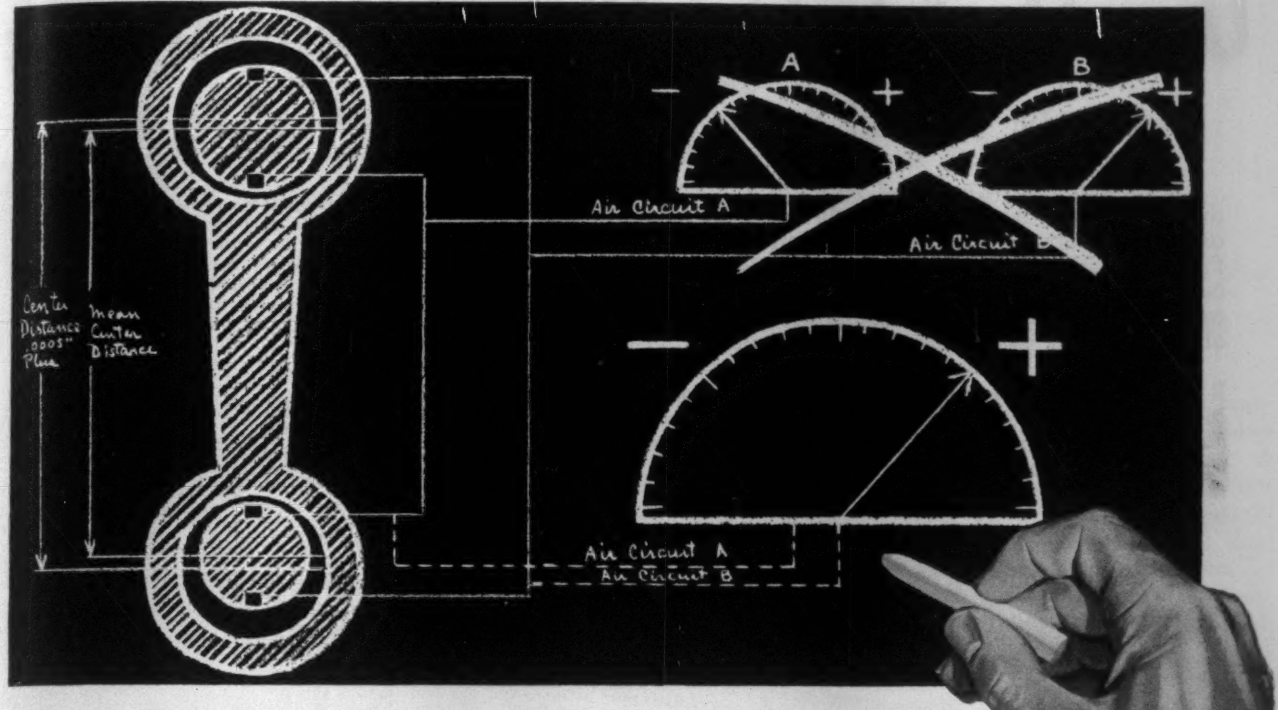
In *Fig.* 5 we show how an internal grinder with and without automatic sizing actually holds size. Notice how drift in size occurs without feedback yet the scatter pattern does not change. With feedback note the scatter pattern, but now the drift in size has disappeared and the machine is holding a mean size.

As a summary, TABLE 1 lists considerations for practical automation. This is what the machine tool industry is delivering to its customers—practical automation.

## What's Your Problem?

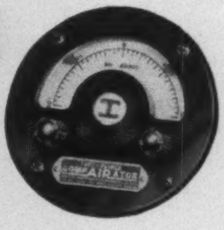
**DO YOU have a knotty problem in your automatic operations or those you plan to install? Perhaps our experience and knowledge of this field can help establish contacts leading to practical solutions.**

**To avail our readers of automation information and tap the vast reservoir of practical know-how across industry, the editors have been performing a special service. If, in planning new automation systems, unfamiliar or new requirements present obstacles, write us concerning your needs and we shall be glad to assist in procuring pertinent data on present practices or in ascertaining suitable equipment obtainable from industrial specialists and consultants. We have been able to help in solving many problems, perhaps we can help you in yours.**



# **NOW!** Gage Center Distance with Just One Dial

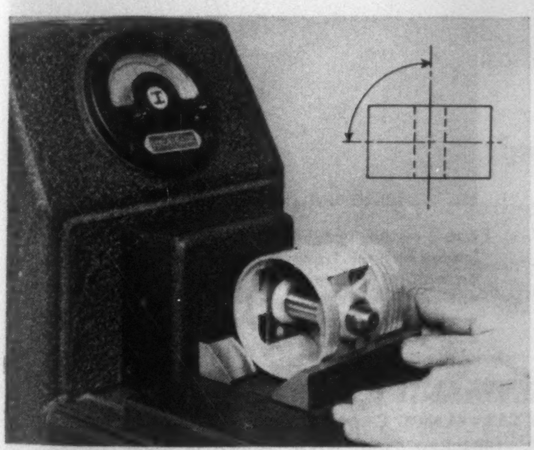
## ...using a Taft-Peirce Comp-U-Tair*



Gage parts twice as fast — and far more easily — with this exclusive T-P *computing* air gage . . . the Comp-U-tair.

Checking a dimensional relationship like center distance, for example, is greatly simplified. The Comp-U-tair measures, computes, and indicates the result on a *single* indicator with *one* pointer. The Comp-U-tair is a *differential air gage,* in which two air circuits are applied to opposing sides of the differential device. Gaging nozzles are placed so that diameter variations cancel each other and have no effect on true center distance reading. Operator reads just one dial, does no calculating, and has an instant, positive indication for every part — in or out of tolerance, plus exact amount and direction of variation.

Streamline your gaging with the unique Comp-U-tair. Call Taft-Peirce to save time and money throughout your inspection operations. As a starter, write for Air Gage Catalog No. 613.



**The Comp-U-tair does many other jobs . . .**

One big time-saver is measuring squareness, shown above. Squareness is indicated on one *dial* with *one pointer.* The Taft-Peirce Comp-U-tair figures as it measures, can be designed to check several dimensional relationships *simultaneously.* Number of dials is cut in half . . . inspection is faster, more accurate.

*Patent Pending

**THE TAFT-PEIRCE FAMILY...**

- **Magnetic Chucks**
- **Precision Gages**
- **Air Gages**
- **Grinding Machines**
- **Lapping Machines**
- **Tool-Room Specialties**

# TAKE IT TO TAFT-PEIRCE

TAFT-PEIRCE MANUFACTURING COMPANY
WOONSOCKET, RHODE ISLAND

T-P Means TOP Precision

*Circle 570 on Inquiry Card*

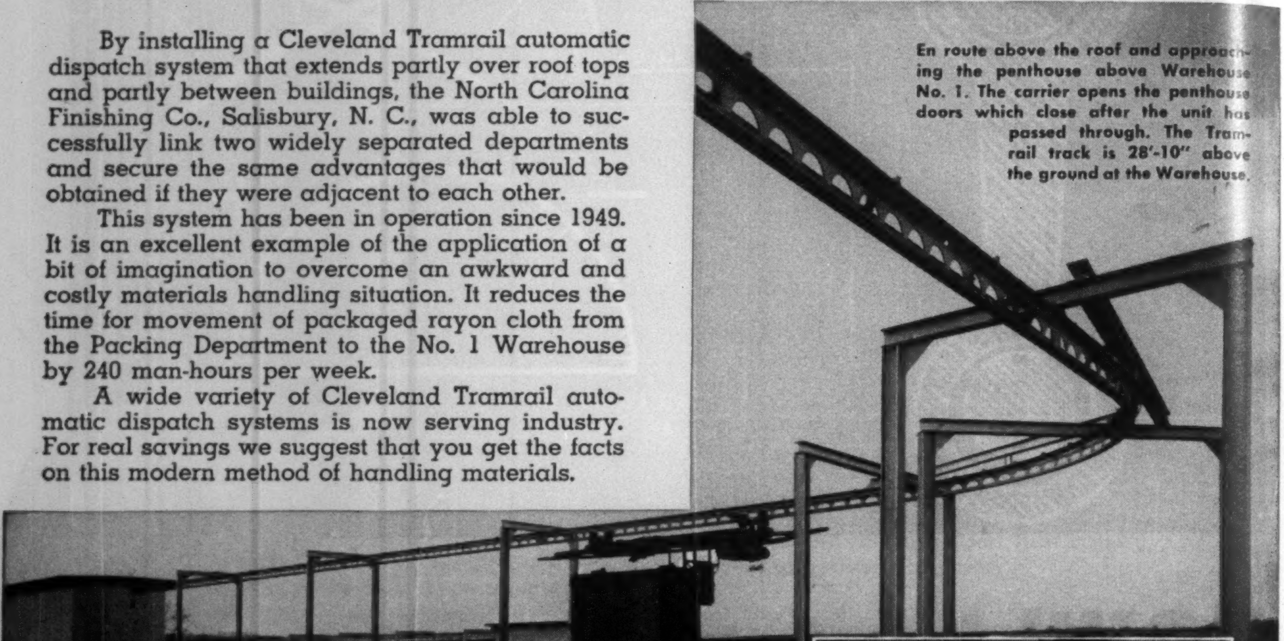
# Uses Roof To Link Distant Departments

## Automatic Tramrail System Saves "240 Man-Hours" Per Week

By installing a Cleveland Tramrail automatic dispatch system that extends partly over roof tops and partly between buildings, the North Carolina Finishing Co., Salisbury, N. C., was able to successfully link two widely separated departments and secure the same advantages that would be obtained if they were adjacent to each other.

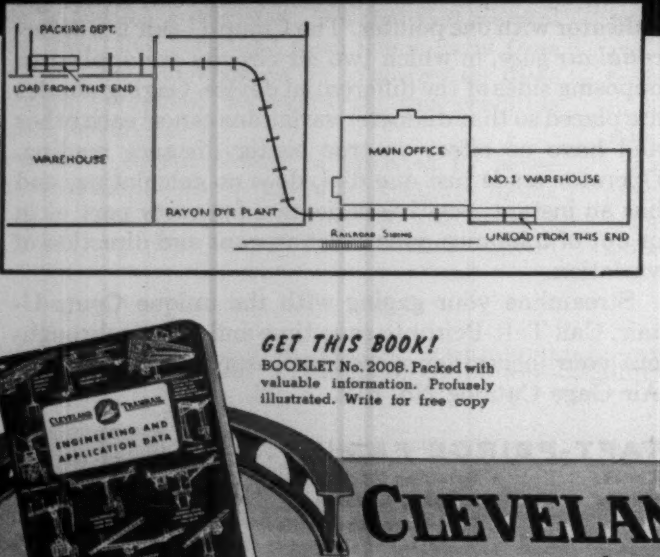
This system has been in operation since 1949. It is an excellent example of the application of a bit of imagination to overcome an awkward and costly materials handling situation. It reduces the time for movement of packaged rayon cloth from the Packing Department to the No. 1 Warehouse by 240 man-hours per week.

A wide variety of Cleveland Tramrail automatic dispatch systems is now serving industry. For real savings we suggest that you get the facts on this modern method of handling materials.



**En route above the roof and approaching the penthouse above Warehouse No. 1. The carrier opens the penthouse doors which close after the unit has passed through. The Tramrail track is 28'-10" above the ground at the Warehouse.**

**6 to 8 cartons weighing 100 to 400 lbs. each are loaded into the Tramrail freight van. The button on wall, at left, sends the van on its way, first upward through ceiling opening, and then forward on outside roof track. The van measures 4'-0" x 8'-0" x 6'-6" high.**


PACKING DEPT.
LOAD FROM THIS END
WAREHOUSE
RAYON DYE PLANT
MAIN OFFICE
NO. 1 WAREHOUSE
RAILROAD SIDING
UNLOAD FROM THIS END

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**THE CLEVELAND CRANE & ENGINEERING CO.**
1305 East 290th Street, Wickliffe, Ohio

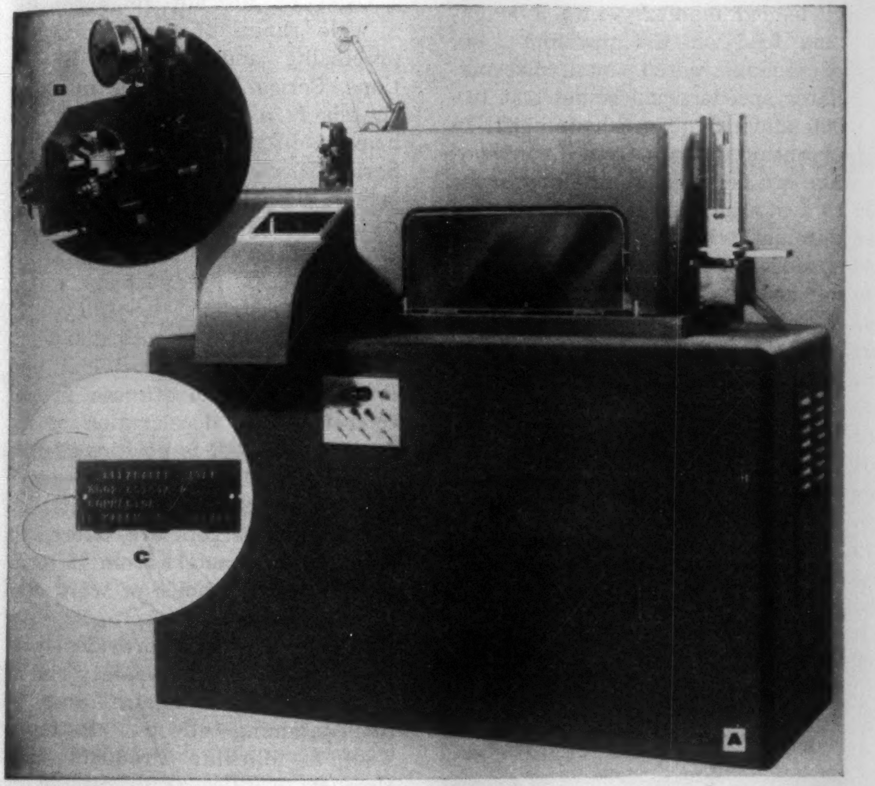
CLEVELAND TRAMRAIL
ENGINEERING AND APPLICATION DATA
CLEVELAND TRAMRAIL
OVERHEAD MATERIALS HANDLING EQUIPMENT

Circle 571 on Inquiry Card

# new equipment

Machines and plant equipment designed for more automatic operations

For detailed information and literature, use card page 17



## Automatic Wiring and Embossing Unit

New machine attaches tying wires while embossing fixed and variable data on metal identification tags at the rate of 75 per minute. Machine can simultaneously emboss sequence numbers, notch plates for coding or sorting and coat tops of embossed characters for easier reading. Without wiring operation, unit performs all its other operations at the rate of up to 100 tags per minute. In order to thread wire into the tag, cut off a uniform length and make a securing twist, unit goes through 15 different mechanical motions within 0.8 second. Wiring unit is used by aircraft manufacturers in tying identification tags for assembly control and to identify replacement parts. **Dashew Business Machines Inc.**, 5886 Smiley Dr., Culver City, Calif.

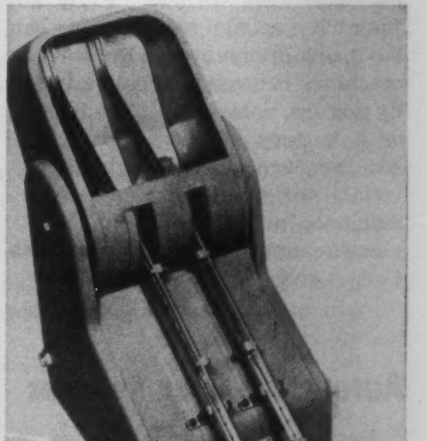
*Circle 401 on Reply Card*

## Small Parts Feeder

Automatic feeding of small production parts is possible with sliding action hopper feeder called Hopperal. Using a gently oscillating motion, Hopperal works fast and efficiently with minimum tumbling of the parts. Parts feeder selectively arranges bolts, nuts, screws, nails, rivets, and other types of small fasteners and parts on an internal track, permitting them to file out in an orderly manner to the outside feed track and down to any required position. A selector gate rejects pieces not properly positioned, allowing only those correctly positioned to flow to the feed track outside the hopper. Firmly supported by the hopper base, this track is rigid enough for extensions to the work operation.

Hopperal can be equipped with single or multiple tracks. It can be designed to feed two different parts from the same hopper, and to release a given number of pieces at a controlled rate of speed. Its versatility permits adaptation to standard machines or integration with specialized ones. Completely self-powered, it becomes an independent assembly unit with the addition of accessory components.

Applications include assembly, inspection, gaging, packaging, processing, grinding, sorting, pro-



duction loading, etc. **Haberstump-Harris Inc.**, 10463 Northlawn Ave., Detroit 4, Mich.

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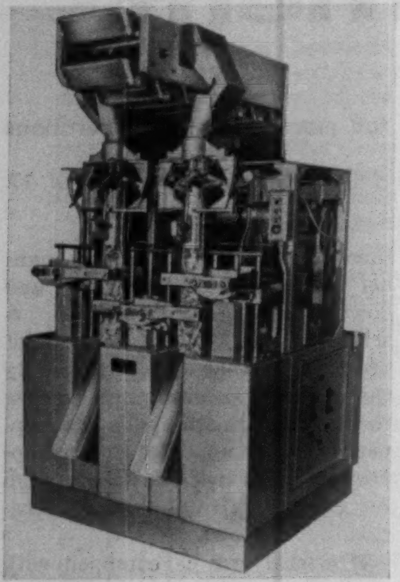


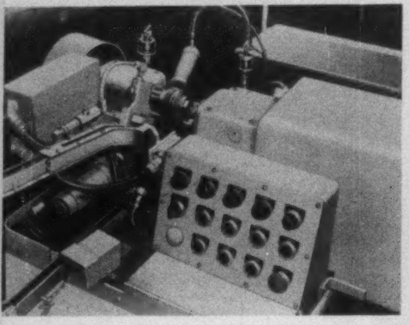
## Strip Packaging

High speed, accurate machine called the Robo-Wrap is designed to form a pillow style package from roll material and fill it with solids, powders, granules, liquids, creams, etc., and heat-seal it. In one continuous operation, the Robo-Wrap unwinds the roll material, forms the pillow type package, seals it, cuts it off, simultaneously measures the correct portion of product and feeds it into the package being formed. Fully adjustable, package size changes can be made in minutes. Robo-Wrap machines can be automatically fed by augurs, volumetric feed devices, or a battery of net weigh scales. All the current heat-sealable materials are suitable for use on the machine, including cellophane, foil, glassine, and coated papers. **Lynch Corp.**, Anderson, Ind.

*Circle 403 on Reply Card*

## Automatic Gear Speeder

Designed to provide precise selection of gears having uniform sound characteristics, fully automated gear speeder includes an electronic ear that automatically inspects gears based on operating sound level. The gear speeder handles the smaller sizes of pinion gears. Gears are automatically loaded, run in both directions in mesh with another gear with and without brake loading, are unloaded, and passed or rejected by the electronic sound discriminator unit whose microphone is placed near the gear mesh area. The sound discriminator unit may be adjusted at any time to the range of audible noise frequency and intensity desired for rejection. Pinions can be fed to the automated speeder unit from a conveyor unit or loaded manually into a magazine feed on the machine. Six of the automated sound discriminator speeders can sound test 14,000 pinions in an 8-hour shift. In operation, pinions from a conveyor line are fed through an input chute to a storage magazine ahead of an automatic loading device on the speeder. At the same time a pinion is loaded in speeding position, a finish tested pinion is dropped into the unloading chute. A diverter in the unloading chute is automatically operated by the electronic sound discriminator to direct unsatisfactory pinions to a table area on top of the speeder unit. Satisfactory pinions pass by the diverter and are directed by the unloading chute back to the conveyor line. Pushbutton controls are included for each machine to facilitate setup operations. Since the machine must operate at minimum sound levels, separate electrical and pneumatic control panels are included. These are mounted a distance from the speeder unit to remove noise sources. The speeder unit is powered by a 1 hp motor. Illustrated machine is sound testing an automatic transmission helical pinion. **National Broach & Machine Co.**, 5600 St. Jean Ave., Detroit 13, Mich.



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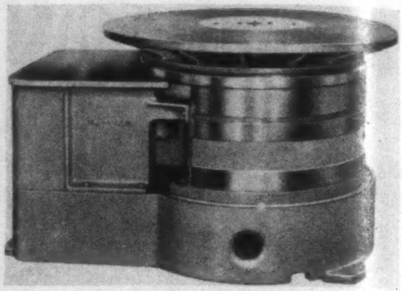

## Indexing Chassis

Used as an aid to automate a wide range of manufacturing, processing and assembly operations, Series H indexing machine chassis is a turret type unit for heavy duty applications. The Series H chassis fills a need for larger diameter turret units that combine ruggedness and accuracy. Unit can handle turret loads in excess of 3500 lb, and has a guaranteed indexing accuracy of ±0.001-inch at a 60-inch diameter.

The unit utilizes a cycloidal type crossover for smoothness in acceleration and deceleration of index. The turret is positioned during work cycles by an independent positive wedge locking device.

Standard turrets are offered in a range of diameters from 42 to 72 inches, with a choice of work stations ranging from six to 32. An electric clutch brake provides cycle variation. Mechanical safety clutch protects the unit against possible tool jamming effects. **Swanson Tool & Machine Products Inc.**, Erie, Pa.

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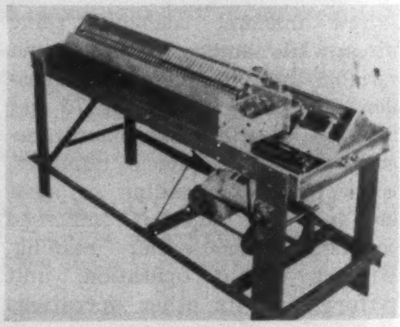

## Resistor Coding

Conveyorized machine for imprinting code numbers on flat type resistors has two feeding stations to assure that the machine will function continuously. A variable speed motor drive permits the operator to vary production from 30 to 45 units per minute. The conveyor pockets are so designed that misplacement of the part is avoided; however, to take care of possible errors, a limit switch is provided on the conveyor to stop the machine. The use of a paste type lacquer ink guarantees quick drying and uninterrupted flow. New machine can be adapted to handle almost any small, flat object. **Industrial Marking Equipment Co.,** 454 Baltic St., Brooklyn 17, N. Y.

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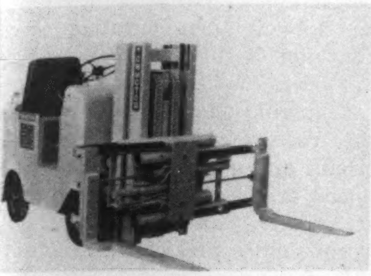

## Improved Lift Truck

Well suited to operations where a lift truck must be used interchangeably as a clamp truck and a fork lift truck and to applications where a variety of widths of pallet loads are handled, fork lift truck features a hydraulic clamp and an offset fork attachment. Hydraulic actuation of the clamp provides for quick adjustment of the forks. Multipurpose clamp and forks are shown attached to a Model 500 fork lift truck equipped with a double telescopic mast and with Towmo-Torque drive, which automatically supplies correct torque to the drive wheels as required by varying operating conditions. The model 500, available with gasoline, LP-gas or diesel power, has a lifting capacity of 5000 lb at 24-inch load center. The double telescoping mast consists of a primary and secondary mast. Because the action of each is controlled separately by hydraulic levers located at the driver's fingertips, the secondary mast can be used for low headroom stacking. In a high stacking operation, both masts are used. **Towmotor Corp.,** 1226 E. 152nd St., Cleveland 10, O.

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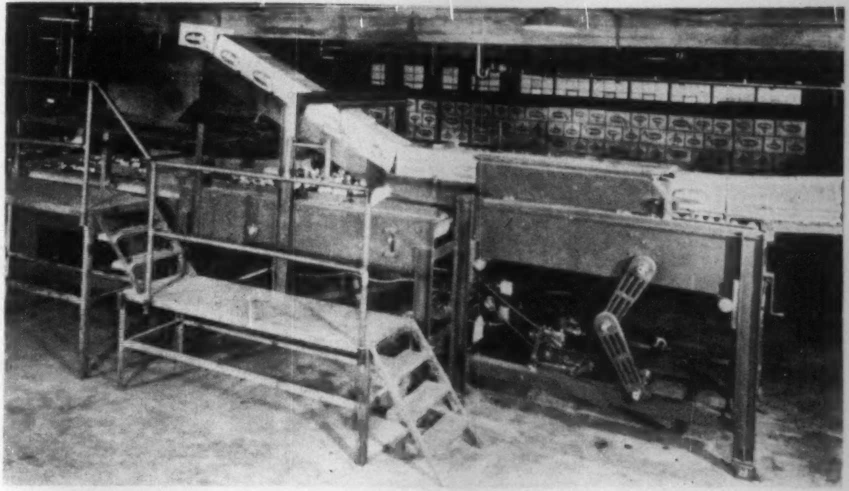

## Can Unloader and Unscrambler

Empty cans are unloaded and unscrambled by new automatic machine. In operation, reshipped cases of cans are placed upside down on a gravity conveyor and are automatically fed to an unloader. The flaps are automatically opened and the cases are gradually raised by two take-off channels. Empty cans slide from the cases onto an unloading belt. Empty cases are then automatically turned upright and moved toward packing areas for reloading with finished goods. After the cans have been discharged from the cases, they are conveyed through a separating mechanism that channels and spaces them onto a series of moving belts with guide rails. The rails then pass them under a set of hooks designed to catch the open ends of the cans and turn them around so that all cans are aligned and traveling closed end forward toward the can collector. The collector then takes them from each lane, places them in single file for conveyance to filling equipment and repacking in the original cases. New machine is available in several models to meet required production line speeds. **A-B-C Packaging Machine Corp.,** Tarpon Springs, Fla.

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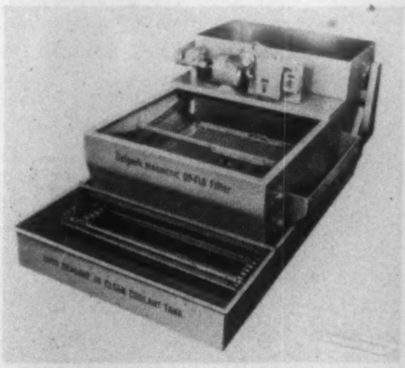

## Separator and Filter

Magnetic separation, permanent filter screen and settling tank are combined in Up-Flo filter which is particularly useful on coarse grinding operations. The method of magnetic separation makes use of a flat magnetic field onto which the liquids are diffused. Principle of design uses the force of gravity to assist the magnetic field.

Liquids that have been exposed to the magnetic field are carried up through the permanent 0.004-inch bar stock screen to remove particles such as abrasives which do not respond to the magnets. The liquid flows into a storage tank where settled particles smaller than 0.004-inch are removed by chain driven flights. The bar stock screen is cleaned by air shakers which shake embedded particles from the screen. This residue with the ferrous particles is removed by separate chain driven flights.

Up-Flo filters are available without magnets for nonferrous metal applications. **Industrial Filtration Co.,** Dept. UM-471, Lebanon, Ind.

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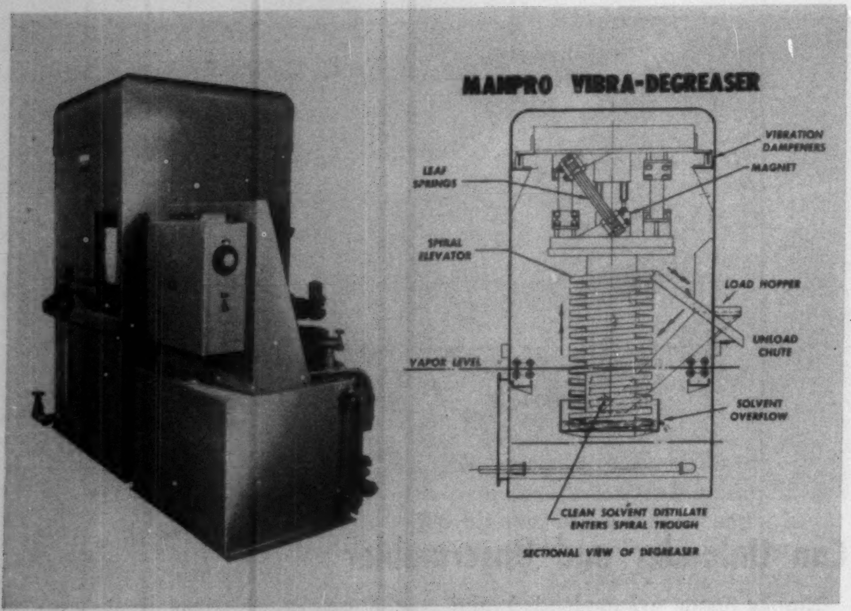

## Metal Parts Cleaning Machine

Capable of cleaning up to 3000 lb of chips or metal parts per hour, while requiring floor space of no more than 5 by 5 ft, new parts cleaner can be synchronized to perform with conveyor and automation systems because it is a fully automatic unit itself. Accurate automatic control of metal cleaning provided by the unit eliminates all manual operation. Unit can be fed by one conveyor and be synchronized by a selector switch to discharge onto another conveyor. The unit moves small parts and chips in a corkscrew circular uphill action, passing parts through a liquid immersion, liquid rinse, and solvent vapor zone. It then emits clean metal materials through an unload chute located 42 in. from ground level. Action of the machine, called the Vibra-Degreaser, involves loading parts to be cleaned into a synchronized hopper, a component of the machine. Parts descend to a pan at the bottom of the spiral trough and then start their progress upward in the trough until they reach the unload chute. The Vibra-Degreaser action is made possible by a combination of flexible, vibrating leaf springs and electromagnets to which the spiral trough is attached. This assembly is energized by a pulsating current creating the vibration that transports the work through the cleaning cycle and onto the unload chute. Vibra-Degreasers were first specially designed to clean chips from metals such as titanium and other high premium alloys. Vapor degreaser is now being applied to the cleaning of metal fasteners, nuts, bolts, rivets, nails and a broad range of screw machine parts, as well as chips from extremely valued alloys. Loading and unloading chutes on the unit can be positioned to work from any side of the machine as may be required in a particular operation. **Manufacturers Processing Co.**, 1360 Hilton Rd., Detroit 20, Mich.

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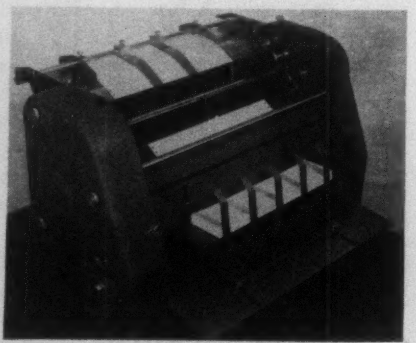

## Forms Burster

Electronic timing and TV dialing for exact automatic form length adjustment are features of new forms burster called the Selec-Tronic. By twisting a dial, 23 different lengths, ranging from 3 to 22 inches, may be handled simply and efficiently.

Length change can be made while the machine is in action, and because of friction feed, one row or both rows of marginal holes may be removed before bursting. Electronic timing mechanism which controls burster action, senses the leading edge of each form as it comes through. Automatically, time is allowed for that length form to pass through before bursting it. Since each form is timed individually, any error from slippage or variation in timing is confined to just one form. Horizontal perforations within a form will be skipped since bursting action does not begin until correct time has been allowed.

Changing the dial setting alters the resistance in the electronic circuit and a new length is set up. Speed of the new burster is rated at 12,500 3½-inch forms per hour. Form guides and chutes are movable for paper widths between 3 and 18 15/16 inches. **Standard Register Co.**, Dayton 1, O.

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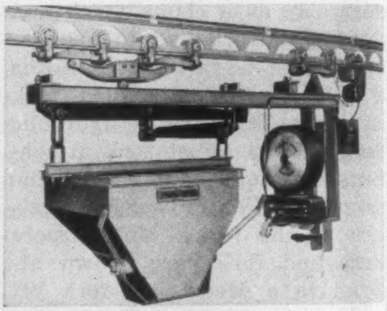
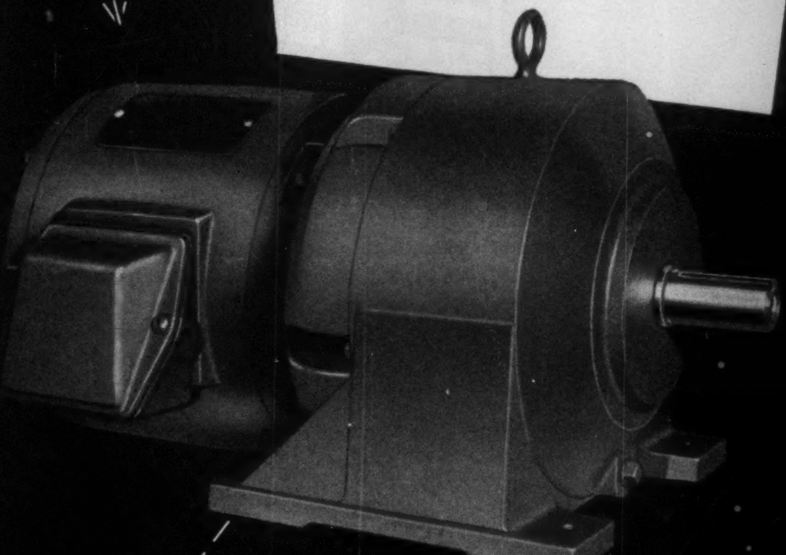


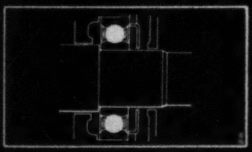
## Traveling Hopper

Designed for handling pottery clay and other bulk materials, tractor-driven traveling hopper with scale has a capacity of 1 cu yd. Hopper is so located with respect to the track on which it travels that an extra large opening is provided at the top for filling. The hopper is emptied by means of a bottom gate which can be manipulated from both sides of the bucket. A 5000-lb dial scale with tare beam enables accurate weighing of ingredients as they are gathered from overhead storage bins. Spring clip markers on the scale facilitate quick weighing

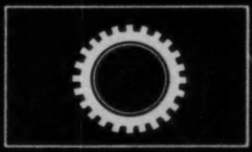
# Don't overlook what you can't see



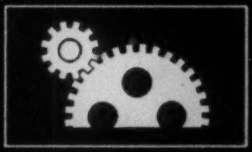
You can't always see what makes a gearmotor outstanding. It's the attention paid to small design details that makes the difference. Here are a few of the details that make the new Reliance Gearmotor stand above the rest.



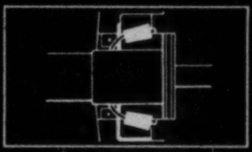
**FOOLPROOF METERMATIC** motor bearing lubrication and oil bath gear lubrication for long-life protection against wear.



**INDUCTION HARDENING** of the tough alloy steel gears gives a perfect combination of wear resistance and strength.



**SIMPLIFIED GEARING** with few moving parts reduces friction losses and lessens chances of breakdown.



**THRUST BEARINGS** handle heavy overhung loads safely by placing strain on the frame instead of the shafts.

*Find out the complete story for yourself— contact your Reliance representative or write for Bulletin E-2408.*

E-1509

REDUCE SPEED

**RELIANCE** ELECTRIC AND ENGINEERING CO.

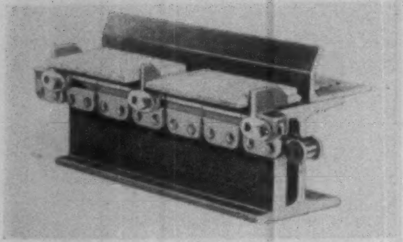
CLEVELAND 10, OHIO · OFFICES IN PRINCIPAL CITIES

Canadian Division: Welland, Ontario

*Circle 572 on Inquiry Card*

when similar batches are made up repeatedly. The load bar supporting the bucket and scale rides on 12 ball bearing equipped wheels. The unit is propelled by a tractor drive at 150 fpm. Control is of the pushbutton automatic accelerating type. **Cleveland Tramrail Div., Cleveland Crane & Engineering Co.,** Wickliffe, O.

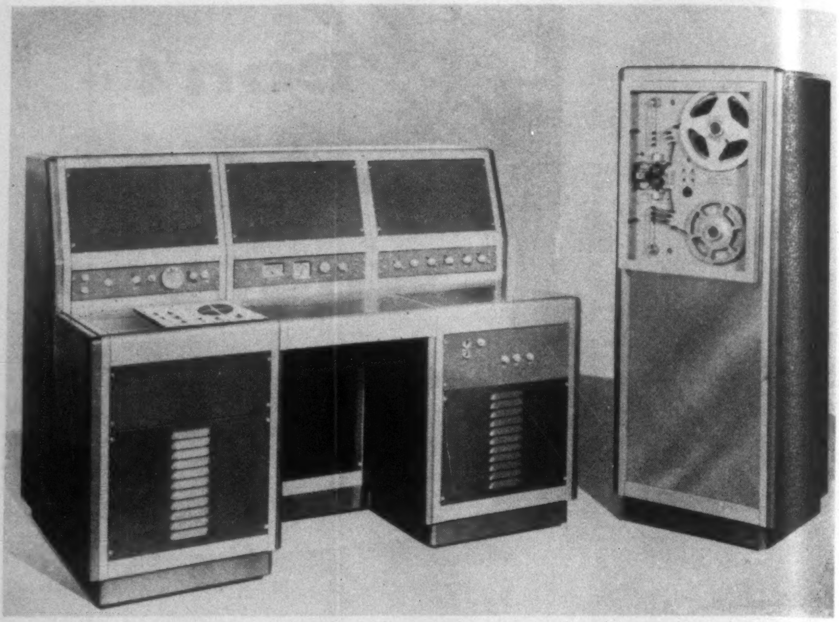
*Circle 412 on Reply Card*



## Chain Feed Conveyor

Designed for precisely controlled high production operations, conveyor is easily adapted for feeding many types of sheet materials and assemblies into processing machines on automated production or assembly lines. Automated operation with punched paper tape control of individual stapling heads is supplied on some units. For volume production, automatic work stops, hopper feeds for materials and electronic controls may be adapted. Used for several years as a component part of large Saranac stapling machines, electromagnetically controlled chain feeding conveyor is now available as a separate item for integration with other types of equipment. On one Saranac container stapling machine, conveyor feeds parts assemblies under stapling heads at speeds up to 100 linear fpm. Feature of conveyor is that materials in process move at constant speed while in motion, but may be instantly stopped while processing operation such as drilling, spot welding, grinding, stapling or assembly, take place. Complete chain feeding deck includes two or more rails along which material is pulled by dogs attached to chain. Chain dogs which move materials are quickly adjusted to change setup for different spacing or size of conveyed pieces. **Saranac Machine Co.,** Benton Harbor, Mich.

*Circle 413 on Reply Card*



## Analog to Digital Converter Systems

Signals from transducers, frequency modulation discriminators, frequency modulation or pulse width modulation magnetic tapes, film readers or other analog sources are accepted by analog to digital converter system and converted to any desired digital code. New converter is high speed unit with a capacity of up to 100,000 conversions per second, 30 mv resolution and 0.1 per cent guaranteed accuracy.

When converter is used with appropriate commutating it will sample, in sequence, data from any number of analog sources. Digital output may be printed out, or used as input to a digital computer. Interim storage of digital data can be accomplished, if desired, by a programmed magnetic tape unit. High speed input commutation switch, digital output magnetic recorders and programming circuits are among features in converter systems. **J. B. Rea Co. Inc.,** 1723 Cloverfield Blvd., Santa Monica, Calif.

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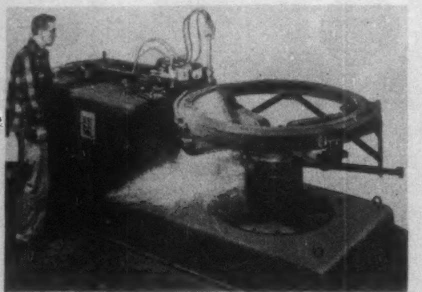


## Flame Machining

Machining teeth in large sprockets and gears is simplified by a new process which involves the precise control of a fast cutting torch, moving on machined ways over a metal blank. The torch is guided by a special cam for control of tooth shapes, sizes and spacings through a pantograph mechanism. Machining is automatic, accurate to tolerances ranging from ±0.007-inch on smaller sprockets to ±0.015-inch on larger sprockets. The method is particularly adaptable to larger sprockets and gears. Almost any size can be handled, in diameters up to 100 inches and up to 3-inch thickness.

Illustrated machine is cutting teeth in a large diameter internal gear for use in roadgrading machinery. The part was produced in less than 30 minutes by flame machining, eliminating boring and machining of the teeth, and turning it out in only one operation to exacting tolerances. **Seaman-Andwall Corp.,** 305-9 N. 25th St., Milwaukee 1, Wis.

*Circle 415 on Reply Card*

# why make your salesman an advertising medium?

Our text for today is taken from the plaint of a young industrial salesman whose company issues a catalog, exhibits in a few trade shows, but does no other advertising.

"When I make a call," he told us, "I not only have to introduce myself—I have to introduce my Company. By the time I have explained who we are and what we make, I have used up a large part of the time the prospect is willing to give me. In my field we sell by picking out from our line the type of products the prospect uses and showing him what these products will do for him. If the Company would use a well-balanced advertising program, I'd have at least 20 more minutes of *real* selling time on every call."

To our way of thinking, that salesman appreciates the value of his own time and his Company's dollars.

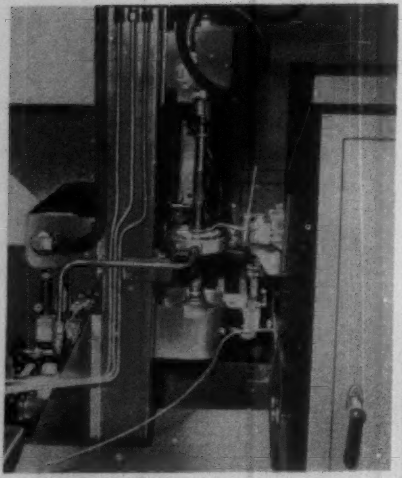
Selling any product to industry involves matching product information to the prospective buyer's problems. That's a job that can be done only by personal selling. That's why you use salesmen—at an average cost of approximately $20 per call.

When you use part of a salesman's time on a job that can be done more cheaply—and far more effectively—by some form of advertising, you are tossing away a considerable portion of your sales dollar. *Your salesman is just about the most expensive advertising medium you can use!*

## National Industrial Advertisers Association, Inc.

271 Madison Avenue, New York 16, New York

**An organization of over 4000 members engaged in the advertising and marketing of industrial products, with local chapters in Albany, Baltimore, Boston, Buffalo, Chicago, Cleveland, Columbus, Dallas-Fort Worth, Denver, Detroit, Hamilton, Ont., Hartford, Houston, Indianapolis, Los Angeles, Milwaukee, Minneapolis-St. Paul, Montreal, Que., Newark, New York, Philadelphia, Pittsburgh, Portland, Rochester, Rockford, St. Louis, San Francisco, Toronto, Ont., Youngstown.**

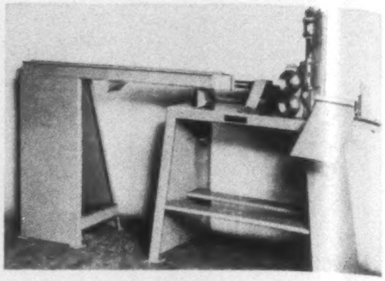


## Induction Hardening

Featuring a high frequency range of 1200 to 1400 kc, induction hardening machine can be equipped with an automatic work handling system and automatic controls for high production runs. It is also well suited to low production operations. The frequency range permits rapid surface hardening of parts requiring shallow case depth and very narrow transition zones between case and core, as well as for any small or thin walled parts. Solid parts such as shafts up to 2 inches in diameter can be hardened, while the capacity for non-solid parts depends upon their geometry.

The machine consists of three primary units: Power supply, oscillator and work unit. The work unit is so designed that tooling can be easily changed. The use of a variable output transformer makes it possible to dial a tool change by varying the heat input to the coil. This can often eliminate the need to change coils when part size or configuration is changed during low production runs. It also eliminates the need for a large stock of expensive coil forms or master dies for use in forming coils. The operator can often form a coil by simply bending it around his fingers. The work and oscillator units can be placed directly in a production line, and, if desired, the power supply unit can be located several hundred feet away in an area of low cost floor space. **Cincinnati Milling Machine Co., Process Machinery Div.**, Cincinnati 9, O.

*Circle 416 on Reply Card*



## Cutoff Machine

Designed for extruded materials, new cutoff machine uses standard components. Air cylinders controlled by limit switches actuate the rolls and cutoff blade. The rolls pull the extruded material, and dies can be made to mark the material being extruded. Speed is dependent on the rate of extrusion. The extruded material is looped before it reaches the roll feed. A limit switch at the end of the conveyor stops the machine if the loop is taken up. Any extruded metal that can be sheared can be accommodated, and any length can be cut. **Klaas Machine & Mfg. Co.**, 4314 E. 49th St., Cleveland 25, O.

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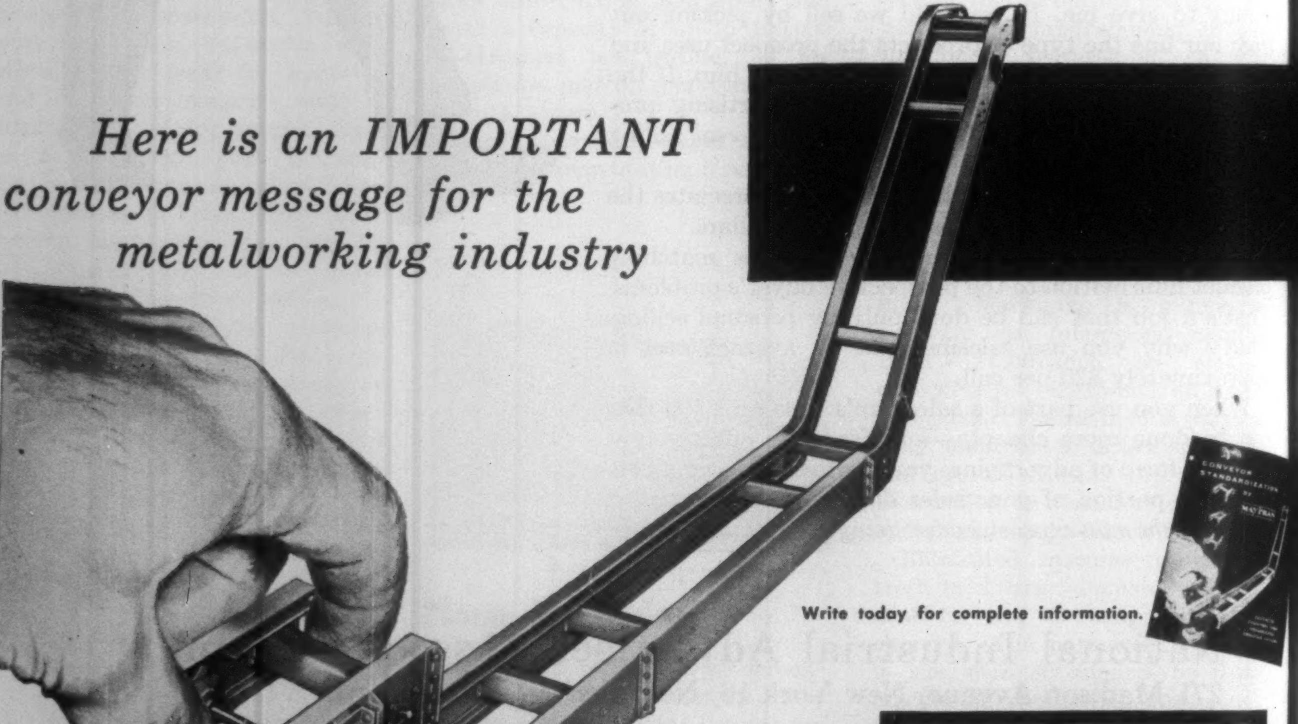


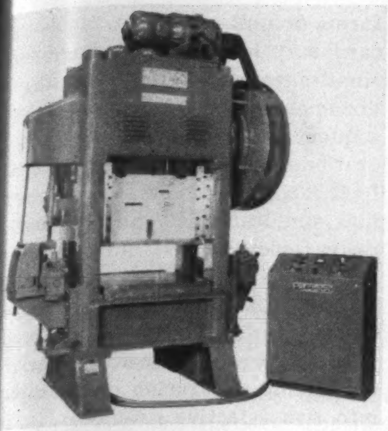
*Here is an IMPORTANT conveyor message for the metalworking industry*

**Write today for complete information.**

**MAY-FRAN**

**ENGINEERING, INC.**

**1781 Clarkstone Road** **Cleveland 12, Ohio**



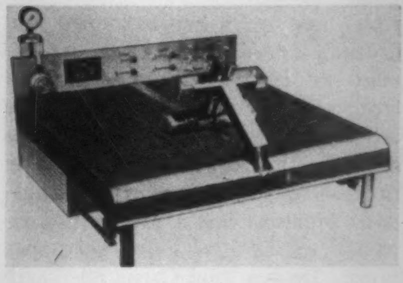
## Automatic Press

Large working capacity is provided with a 15-inch side opening accommodating work up to 14 inches wide on 75-ton automatic Flexopress. Automatic feed is infinitely adjustable up to 8 inches per stroke. The hardened and ground double feed rolls have 360-degree cam lifters. Drive gear teeth are always on pitch center regardless of the material thickness. A scrap cutter is mounted integral with the feed rolls. Low ram inertia makes possible speeds up to 370 strokes per minute. Contributing to this low inertia are the lightweight aluminum alloy ram construction, the antifriction bearings and double air cylinder counterbalance.

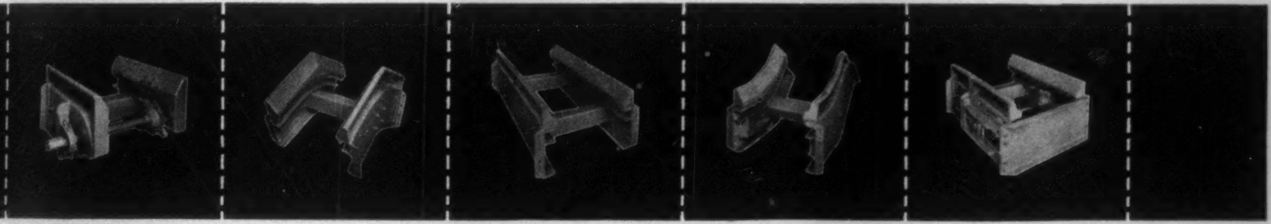
The electric control can be installed in a console, a pendant or a machine mounted panel. The control provides single-stroke, continuous operation; inching; variable top stop control; variable sequence inch control; key locking; motor reverse; motor start; emergency stop; variable motor speed; key locking stroke counter; and a visible tachometer. Lubrication is continuous automatic force feed; automatic shutdown is provided in the event of pressure failure. **Precision Welder & Flexopress Corp.,** Cincinnati, O.

*Circle 418 on Reply Card*

## Coaxial-Lead Processor



Completely automatic cutting and forming of coaxial leads of resistors, capacitors, diodes, coils and similar components is now possible with new lead former. Machine cuts leads to any desired length and forms them to any desired shape. It is available in three models of two, four or six slides, depending on final lead shape desired. The machine is pneumatically operated and electrically controlled. At 60 to 80 lb. pressure, air consumption is negligible. In operation, components are fed to the machine down a zig-zag chute from which they are released individually to a clamp which holds them securely during the cutting and forming operation. Chute feed is normally manual, but optional card, roll or hopper feeds are available. Clamping occurs on the coaxial leads close to the body rather than on the body itself, preventing any possible injury to delicate parts. Slides operate in pairs on the clamped leads to form them into the desired shapes. Both



NOW YOU CAN ASSEMBLE YOUR OWN "CUSTOMIZED" CONVEYORS FROM PRE-FABRICATED STANDARD SECTIONS.

If your plant produces stampings, formed metal parts, castings or forgings . . . if you have a byproduct such as automotive scrap, chips and turnings . . . the MAY-FRAN conveyor standardization program will provide your company with savings never before possible.

Through standardization, MAY-FRAN now makes it possible to assemble individual components into virtually any type of conveyor to handle a wide range of products or materials. Straight sections . . . concave or convex sections . . . take-up charge sections and discharge-end sections can be furnished to meet specific requirements of belt width as well as load bearing and volume capacities.

Even after they are installed, MAY-FRAN conveyors can be dis-assembled and re-assembled in other plant locations . . . to handle other products. Standardized conveyors can be lengthened, shortened or modified in almost any way . . . and at minimum cost.

Pre-fabricated conveyor sections can be furnished rapidly and inexpensively. The individual components provide users with the ultimate in flexibility. MAY-FRAN hinged-steel conveyor belting is used on the Standardized units. Belting is available in widths from 6 inches to 6 feet in any length. Solid and perforated links are available in pitch lengths from 2½ to 9 inches.

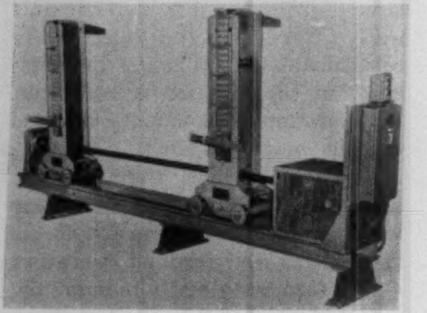
MAY-FRAN . . . a name long recognized in the materials handling field . . . is first again with standardized components for your customized installations.

[illegible]-MP

*Circle 574 on Inquiry Card*

slides and ways are hardened and ground. As the finished component is ejected, it is separated from the scrap and the next one is released from the chute into the clamp. Control of this continuing process may be automatic or manual. Machine has a production capacity of 5000 or more parts per hour. **Design Tool Corp.,** 80 Washington St., New York, N. Y.

*Circle 419 on Reply Card*



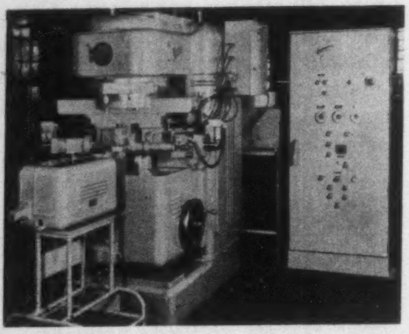
## Bar Unloader

Designed to unload pieces of bar or tubing from a production machine to a high tote box, new bar unloader has one stationary tower and one movable elevator so that it can be adjusted to handle pieces from 3 to 12 ft in length and from 1½ to 3 inches in diameter, at a variable rate of speed. The completed workpiece rolls down an incline until it is picked by the cleats of the two elevating conveyors which operate in unison. It is lifted to the top of the conveyors and over to the other side of the unloading machine where it rolls into the tote box. Power is furnished by a ½ hp, 220 to 440 v, three-phase motor operating through a square shaft which motivates both elevating conveyors. **Feedall Inc.,** Willoughby, O.

*Circle 420 on Reply Card*

## Gear Finisher

New line which consists of an underpass gear shaver with vibrating hopper feed, automatic loading, a three-way probe type gear classifier and control panel, automatically finishes gears at the rate of 260 per hour. In addition to controlling the operation of the machine, the control panel counts correct size gears and keeps track of oversize or undersize gears on both a percentage of production and total count basis. A feedback system actuated by the gear classifier through the control panel automatically corrects center distance when gears are undersize or oversize. If this condition persists, the machine shuts down automatically for required corrections.



Outside diameter on the stub arbors is held within 0.6873 to 0.6875-inch, which gives a light press fit between gear bore and stub arbors when the gear is being shaved. After the gears are shaved ,they pass through a chute to the three-way gear selector, with correct size gears passing straight through. Any undersize or oversize gears are diverted, with the control panel counting each one. This quality control setup with feedback system checks every shaved gear for size and gives assurance that every gear will be within specified tolerances. **Michigan Tool Co.,** 7171 E. McNichols Rd., Detroit 12, Mich.

*Circle 421 on Reply Card*

## High Speed Printer

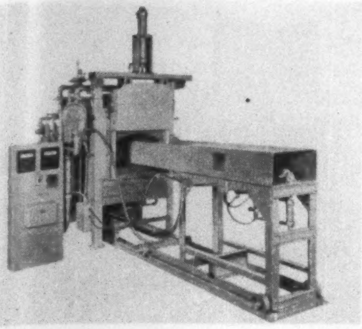
Designed for large volume tabulating and transcribing operations, Model G-101 high speed printer and punch uses punched cards as the input media, and prints 900 lines per minute on continuous forms or unit cards. A tabulating card may be printed and punched simultaneously. Thus, new source documents may be created for subsequent automatic accounting operations. The G-101 with its dual feed can process two separate card files simultaneously and automatically select desired data from either or both without merging or collating the files themselves. Each of the two feeds may be equipped with a secondary receiving stacker permitting separation of the cards into two selective groups.

The reading unit feeds and senses one or two separate files of source records in the form of standard punched tabulating cards. Each feed has three sensing stations, permitting printing three lines from each input card. The console houses electronic devices which convert the electrically sensed punched data into impulses which actuate the printing and punching mechanisms and electronic counters. Because the console is connected to the other units by cable, it may be placed at any convenient distance. One or two auxiliary printers may be connected to the primary printer to produce additional documents and/or reports simultaneously from one passage of the cards. **Burroughs Corp., Special Machines Dept.,** 219 Fourth Ave., New York 3, N. Y.

*Circle 422 on Reply Card*

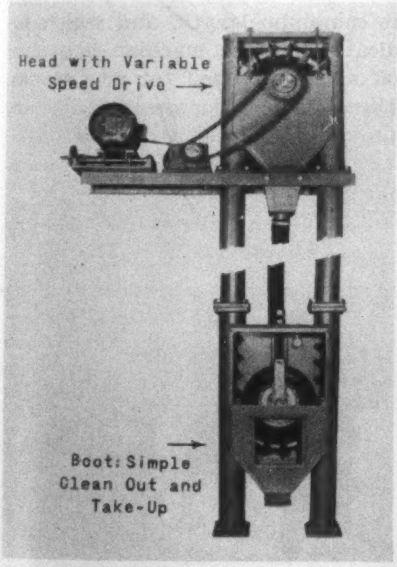
## Aluminum Melter

Designed to reduce furnace maintenance costs by eliminating the throwing of metal against refractory, new aluminum melting furnace of the nontilting type has an automatic loading tray. Furnace is similar to other Eclipse dry hearth furnaces except that the burners fire vertically from the furnace roof. Maintenance costs are lowered because the roof or arch hangs from the furnace frame and does not bear on the side walls. Thus the sidewalls can be rebricked without disturbing the arch. The operator loads risers, gates and ingots into the tray of the loader. When the furnace is ready for recharging, actuation of an air valve loads the metal automatically. Air cylinders power the load tray which operates as follows: When the start button



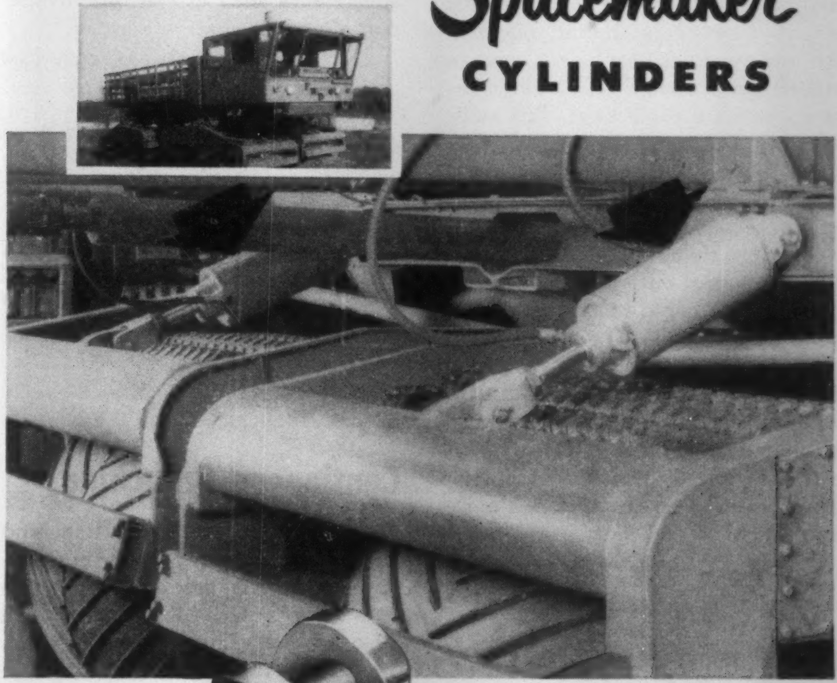
is pushed, the carriage moves to the door of the furnace; the door opens, actuating a limit switch that turns the melting burner to low fire; the loading tray tilts up to the sloping hearth (illustrated); ram retracts; door closes; carriage returns for the next load. The burner goes back to high fire to melt the new load. Packaged control center which includes two indicating controllers, one for each burner, is furnished. Units control the automatic temperature control valves which modulate the air supplied to the burner from the blower. **Eclipse Fuel Engineering Co.**, 1002 Buchanan St., Rockford, Ill.

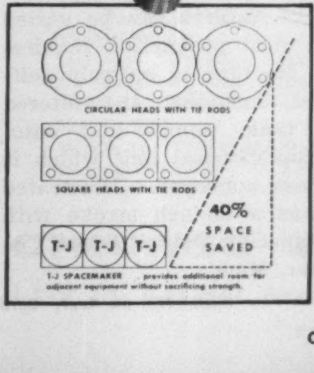
*Circle 423 on Reply Card*


Head with Variable Speed Drive
Boot: Simple Clean Out and Take-Up

## Cable-Bucket Elevator

Used for elevating free flowing materials such as welding flux, gravel, foundry sand, coal, plastic powder, chemicals and food products, new cable elevator is called the Cableveyor. The unit is available with 4, 8 or 12-inch diameter




CIRCULAR HEADS WITH TIE RODS
SQUARE HEADS WITH TIE RODS
40% SPACE SAVED
T-J
T-J
T-J
T-J SPACEMAKER ... provides additional room for adjacent equipment without sacrificing strength.

Arctic Cargo Carrier Depends On T-J Spacemaker CYLINDERS

ALL MODELS... OFF SHELF DELIVERY

Saves 40% Space
No Tie Rods...
Greater Strength

Differential axle loading through T-J Spacemaker Air Cylinders forms a controlled walking beam in this Tera-cruiser, designed and produced for the Army Ordnance Corps by the Four Wheel Drive Co., Clintonville, Wis.

Weight of cylinders was important factor in choosing T-J Spacemakers, which reduce weight while providing same displacement and extra high safety factor. Fast delivery and space-saving features also favored T-J. Exclusive with T-J are new Super Cushion Flexible Seals for Air (to 200 P.S.I.) . . . and New Self-Aligning Master Cushion for Oil (to 750 P.S.I.). Hard chrome plated bodies and piston rods are standard, at no extra cost. Wide range of styles, capacities . . . 64,000 combinations *off the shelf!* Write for bulletin SM-155-3. The Tomkins-Johnson Co., Jackson, Mich.

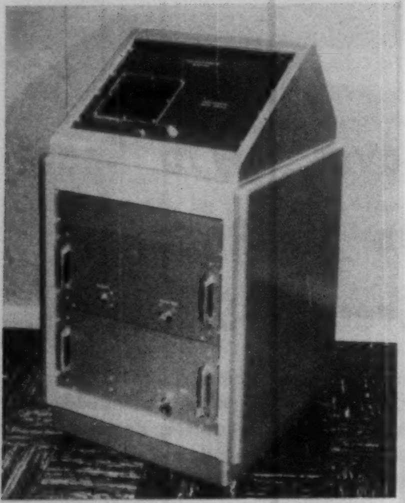
MEETS WITH ALL JIC RECOMMENDATIONS

T-J TOMKINS-JOHNSON
RIVITORS . AIR AND HYDRAULIC CYLINDERS . CUTTERS . CLINCHORS

*Circle 575 on Inquiry Card*

tubes. Either center discharge chute for low speed of 60 fpm or side discharge for high speed operation up to 250 fpm is available. The Cableveyor consists of standard steel cable carrying concave stamped or cast metal buckets, uniformly spaced by heavy springs under compression. A flexible connection joins cable ends. For sanitary applications, springs are covered by synthetic tubing spacers under compression, effectively sealing out conveyed materials. There are no rivets, bolts or other fastenings to wear out, and the design permits the cable to flex naturally under low stress. The use of pneumatic rubber tired drive and take-up wheels eliminates sprockets. A take-up screw provides adjustment for cable stretch. Head with variable speed drive is available. **Hapman Conveyors Inc.,** Kalamazoo, Mich.

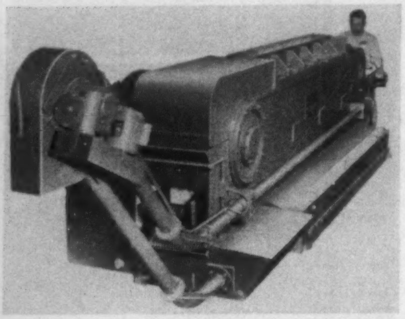
*Circle 424 on Reply Card*



## Digital Ratiometer

High speed electronic digitizing is employed in four-digit ratiometer which is useful in many automatic control applications, such as digital indication of mechanical position, process data logging, checking of precision resistance components and control of resistance winding machines. Model 330 ratiometer provides a discrete four-digit indication of the ratio between two voltages or resistances stable to 0.01 per cent. The ratiometer measurements are independent of reference excitation accuracy. Readings take less than 10 milliseconds, and up to 60 channels may be scanned per second. In addition to a visual display, provisions are included for a digital readout to printers or card and tape punches. **Franklin Electronics Inc.,** E. 4th St., Bridgeport, Pa.

*Circle 425 on Reply Card*

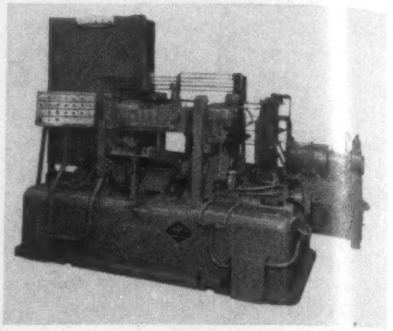


## Continuous Broaching

Fixture locking, operation and unloading of heavy duty, horizontal continuous broaching machine are fully automatic; loading can also be done automatically when required. Longer broach life and extremely fine finishes are made possible because of the heavy, rigid construction of the machine. An oversize bull gear provides positive pulling power, extra weight and smooth operation required for fine finishes. Easy, safe loading and unloading of a wide variety of work sizes and shapes are made possible by the extra fixture clearance formed by the large radius from the chain axis to the outer machine frame. A safety interlock device prevents operation until parts are positively positioned in the fixtures.

Cutting speeds up to 40 fpm can be obtained from the heavy duty twin chain electric-mechanical drive. Other speeds can be obtained through simple change gears. Fixtures are the hammer lock type, automatically located, locked, opened and emptied. The number of fixtures can be varied to meet most production requirements. Machine is entirely self-contained, including the filtered coolant tank, pumps and automatic chip disposal unit which is an endless conveyor. Illustrated model has a 90-inch stroke with 15-ton capacity. **Detroit Boach Co.,** Rochester, Mich.

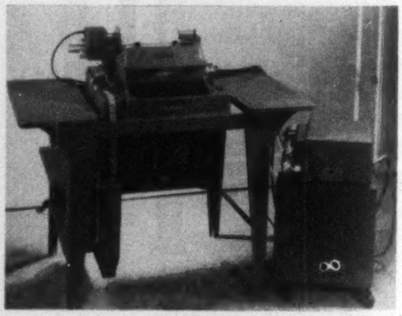
*Circle 426 on Reply Card*



## Center Lapping Machine

New concept in center lapping high production parts is provided by completely automatic machine. In operation, parts are fed from a conveyor onto an inclined magazine loader, then set automatically in the workholding fixture, hydraulically clamped, center lapped on both ends and ejected onto the unload track at the rate of 300 pieces per hour. The new machine uses two center lapping units. Each is equipped with an automatic dresser which dresses the stone after each cycle or as required, and resets itself to adjust for amount of stone removed. The units are also equipped with automatic control panel lights which flash *On* when stones have been used to minimum length, and which indicate that the machine has shut off and reset itself for new stones. Micrometer adjustment dials are provided to adjust stones on initial setup. **Industrial Metal Products Corp.,** Lansing, Mich.

*Circle 427 on Reply Card*

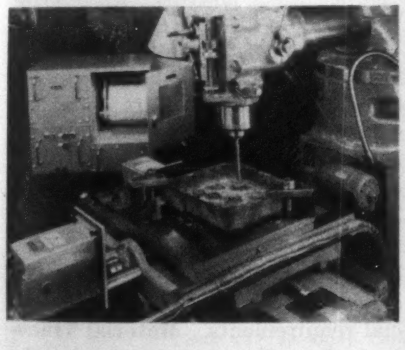


## Tape Typewriter

Controlled entirely by punched paper tape, machine types personalized letters, invoices, orders and other documents automatically at the rate of 100 words per minute. Two punched paper tapes are required in this operation. One tape contains the date and body of the document; the other tape is comprised of the name and address of the person to whom the document is addressed (also the salutation, if the document is a letter). The complete automatic operation from tape eliminates errors, speeds up the preparation of documents and cuts costs.

One application of the Flexowriter Duplex machine is in the typing of personalized letters from punched tape. The tape in the reader of the Flexowriter causes the machine to type the date, and line space down to the position for the inside address. At this point, a code in the tape switches the operation automatically to the motorized tape reader which actuates the Flexowriter causing it to type the name, address and salutation automatically. When this information has been typed, a code switches back to the Flexowriter tape which then types the remainder of the letter. The unit is used in banks, insurance companies, religious organizations, manufacturing plants and many other businesses. **Commercial Controls Corp.,** One Leighton Ave., Rochester 2, N. Y.

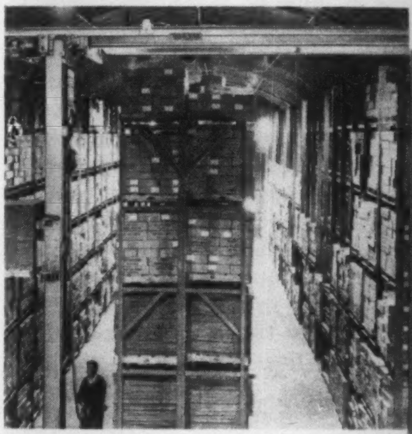
*Circle 428 on Reply Card*



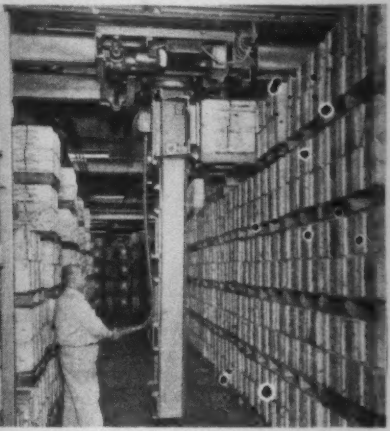
## Automatic Positioning

Ideal for repetitive runs in light manufacturing and small machine shops, Binotrol automatic positioning table is controlled by means of punched tape system. The system was developed to control the Jones & Lamson No. 7 turret lathe, making its operation completely automatic. In this system, all operating instructions are punched on a tape, and the Binotrol system reads the tape and

CHICAGO TRAMRAIL **TRAK-RAK** STORAGE SYSTEMS



Palletized Materials Storage at Oneida Limited

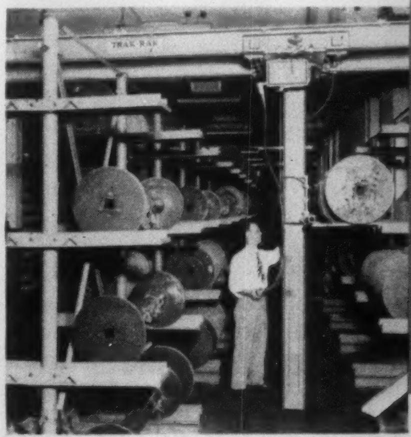


Screw Machine Parts Storage at Chicago Screw Co.

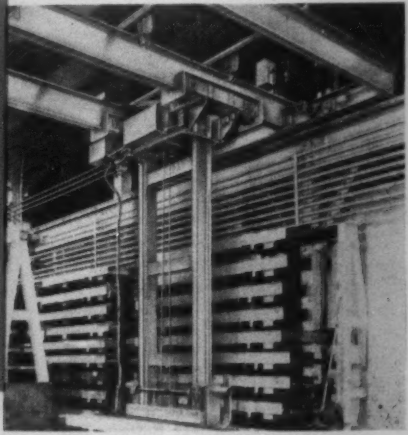
**Bar Stock**
**Palletized Materials**
**Skid Boxes**
**Warp Beams**
*AND MANY OTHER MATERIALS*

now handled and stored in many leading industrial and manufacturing plants by TRAK-RAK Systems

- —to use narrow aisles and maximum stacking height to increase present storage space by as much as 90 per cent
- —to reduce handling costs and manpower
- —to provide 100 per cent selectivity in storage and removal.



Warp Beam Storage Utilizing 90% of Height



Bar Stock Storage and Handling by Saw Man

**What's YOUR problem?**

Do you need more storage space? TRAK-RAK saved one firm from building an additional $60,000 warehouse. Is handling time-consuming and costly? TRAK-RAK cut a 2½ hr. handling time to 30 minutes and a four-man team to two men. In another installation TRAK-RAK saved many man hours due to the simplicity and maneuverability of this one-man pendant push-button control system and the selectivity in placing materials in and out of the storage area.

**Write for TRAK-RAK Applications**—A 20-page illustrated booklet explaining the TRAK-RAK Handling and Storage System; illustrates and describes installations in fourteen widely different industries. Ask for Bulletin TRC-101.

**CHICAGO TRAMRAIL** CORPORATION
**1306 So. Kostner Avenue • Chicago 23, Illinois**

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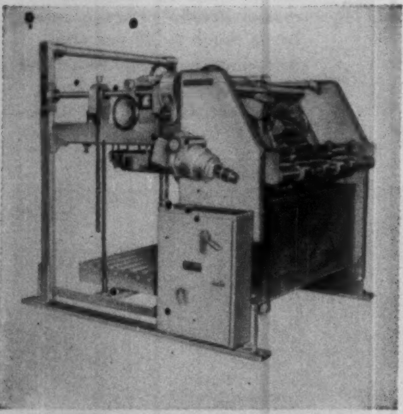
DEXTER
AUTOMATIC
METAL SHEET
FEEDER

**Metal sheets,** automatically separated, picked up and advanced one at a time to feeding—in point of machine to which it is attached at speeds up to 150 sheets per minute.

Should two sheets adhere, they are automatically transferred to a reject tray. Rubber suction mouthpieces and drop rollers prevent scratching.

**Standard Feeder** handles metal sheets from 14" x 18" up to 36" x 44" between 24 and 38 gauge stock. Feeders for larger size and heavier gauge metal sheets also available.



**Continuous reloading** avoids machine stoppage. New loads are placed in feeding position, while machine is operating, thus maintaining continuous automation cycle.

Dexter Feeder may be attached to Metal Litho Presses, Coating Machines, Sorting Machines, Shears, Slitters, Sprayers, Punch Presses, Stove Pipe Machines, Buffers and numerous other metal working machines.

Custom built sheet feeders for handling paper, cardboard, corrugated and other types of sheets are available to meet specific requirements. Inquiries invited.

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DEXTER
FOLDER COMPANY
*General Sales Offices*
330 WEST 42ND STREET
NEW YORK 36, N. Y.

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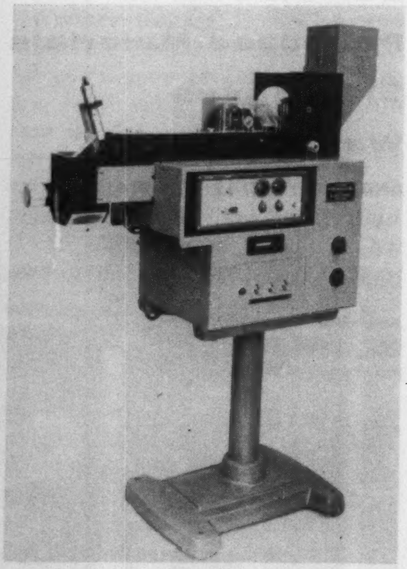
controls the motion of the table.

The table can be used in combination with a drilling machine, miller, or any other common machine tool to ream, tap, mill, or perform any of the usual machine shop operations. The entire sequence of operations is permanently preserved on tape, which can be filed away and reused at any time.

In operation, the positions of the two lead screws are continually being compared with the required positions as indicated by the punched tape. When there is a difference in position, a voltage is applied to two motors, one for the *X* and one for the *Y* position, which drive the lead screws to the required position. **Barnes Engineering Co.,** Stamford, Conn.

*Circle 429 on Reply Card*



## Counting Machine

Used to count items for wrapping machines, bottles, boxes and other containers, universal machine is designed for high speed precision counting of a wide variety of small objects. Its design permits changeover from one item to another without additional guides or other equipment, making it especially useful for producers who have short runs of a number of products. Parts to be counted are placed in the hopper and the desired batch quantity is set on the counting instrument. The machine then sorts, counts, and divides the objects into the preset quantities. They can be either dispensed from the machine as a batch or diverted singly through alternate chutes. Heat sealing wrapping machines and conveyors are easily controlled by this equipment. **Delta Engineering Corp.,** 88 Broad St., Boston, Mass.

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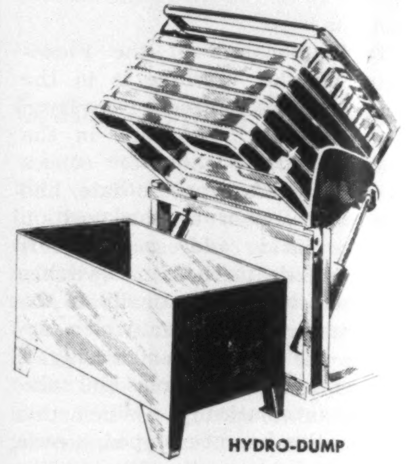


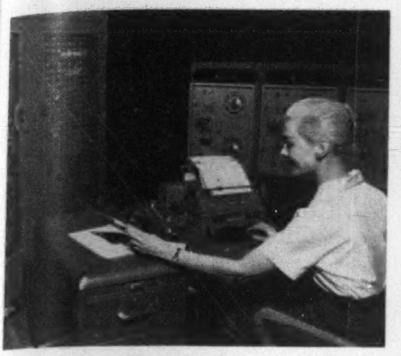
## Lifter and Dumper

New line of cable lift and hydraulic tilt dumping apparatus includes a type and model suitable for handling most average lifting-dumping problems. Automatic or hold-down pushbutton controlled units are available in all models. Included are low level, standard, high level and dumbwaiter types, with dump heights ranging from 12 inches on the low level type to maximum ceiling height on the high level models. Lift speed for cable models ranges from 20 to 50 fpm and the tilt speed on hydraulic models ranges from 20 to 30 seconds for the dump cycle time. Capacities of 1000 to 5000 lb are available; special sizes and capacities can be designed for special requirements. **Material Transportation Co.,** 400 N. Lexington Ave., Dept. 25, Chicago 11, Ill.

*Circle 431 on Reply Card*

## Data File Processor

An electronic memory system which reduces the contents of 1600 conventional file cabinet drawers to less than 3 cu ft of space, new file processor also feeds desired information via magnetic tape to a companion electronic computer. The two units are known as the

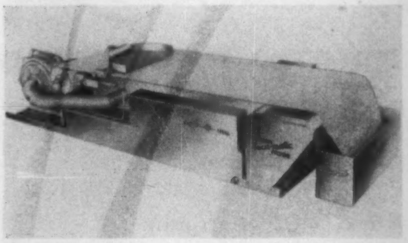


ELECOM 125 system. The file processor automatically sequences, selects, collates and separates information recorded on tape. It can be used for billing, taking inventory, figuring salesmen's commissions and other routine functions. An advantage of the file processor is that it will relieve its companion computer of handling many routine business data operations so that the computer, working independently of the file processor, can concentrate on fast and selective computation. The file processor is operated by means of a punched tape reader or typewriter keyboard which keys the unit as to which digits in an item are significant for the operation about to take place. The operator at the keyboard selects the kind of operation he wishes to carry out by pushing an appropriate button at the control panel. After the pattern is chosen at the keyboard, the rest of the operation is automatic except for necessary changing of reels. As many as 30 items per second can be processed. Results are recorded on magnetic tape which can be fed to a high speed printer for visual study or to the computer for further processing. **Underwood Corp.,** One Park Ave., New York 16, N. Y.

*Circle 432 on Reply Card*

## Vacuum Coolant Filter

Completely automatic and self-cleaning, new filter called the Vac-40 is designed for use on grinders, hones and other machine tools where continuous and effective filtration of coolants is desired. It employs vacuum rather than gravity and is capable of delivering high flow rates in sustained operation. Using a specially fabricated paper as its filtration medium, the Vac-40 delivers dry sludge with little coolant carryover, thus minimizing coolant loss. The redesigned unit is compactly constructed so that it will easily fit into the space normally required by a sump tank. The paper filter medium is supported by an endless fabric belt which in turn is carried on a wire mesh belt which revolves continuously on a chain sprocket drive. A large vacuum chamber is located directly beneath this belt, and the vacuum tends to hold the paper tightly against the supporting screen. Dirty coolant flows by gravity from a baffled distributor onto the filter paper directly over the vacuum chamber. Coolant is uniformly distributed over the entire width of the paper surface. Owing to pressure differential created by the powerful vacuum, the coolant is filtered rapidly through the paper into the vacuum chamber. The clean coolant drains into the clean coolant sump, and is then delivered back to the machine tool by the supply pump. A liquid level sight glass is installed in the clean coolant sump so that the machine tool operator can instantly determine the coolant level. Solid particles removed from the coolant are deposited on the paper, and when caked so thick that suction can no longer be effectively maintained through the belt, the belt is automatically indexed forward by a vacuum switch. This provides a new filter area, allowing continuous operation and preventing shutdown of the unit for cleaning. When the unit indexes, previously collected sludge and dirty paper are discharged into the unit's tote box. The Vac-40 is also provided with an automatic overflow. Should there be a temporary loss of vacuum or clogging of the unit, the pump continues to deliver coolant to the work. **U. S. Hoffman Machinery Corp.,** Industrial Div., 103 Fourth Ave., New York 3, N. Y.



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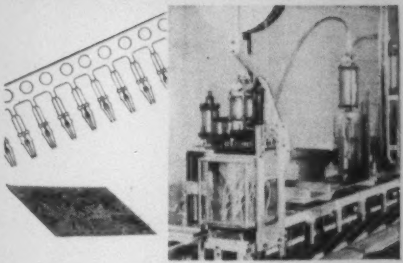
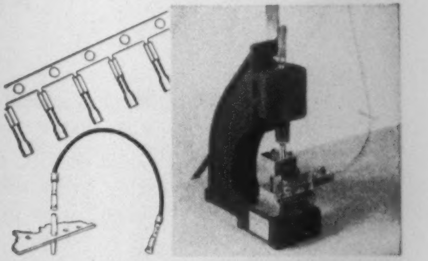
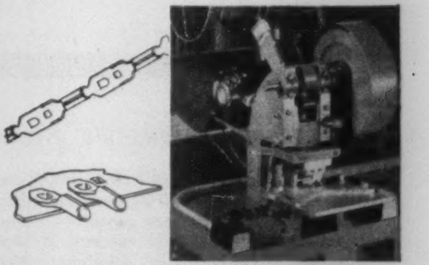
a complete line of
Printed Circuit Hardware
and
Terminal Inserting Equipment



**Tubular Pin Terminals**—Insert automatically into printed circuit board at huge production savings. Snap into position with positive locking action by means of self-retaining snap-in feature. Double ends permit wrapping or inserting leads at either end. Ask for Bulletins 550 and 551.



**Solderless Wire Disconnect Female Terminals**—Speedily applied to leads by means of cost-saving automatic equipment. Fits quickly and firmly to tubular pin terminals. Solderless wire crimp can be varied to fit various size insulated wires. Ask for Bulletin 553.



**Line Cord Interlock Terminals**—For single or multiple lead connections. Another Malco automation development to provide production short cuts and assembly economy. Terminals are staked quickly and firmly into printed circuit boards. Ask for Bulletin 554.

*Malco printed circuit hardware can be engineered to your specific requirements. Give us the facts about your operation. We'll show you how your costs can be lowered and your production increased. Ask for Bulletin 551.*

Malco TOOL and MANUFACTURING CO.
4017 W. Lake St., Chicago 24, Ill.

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**AUTOMATIC PACKAGING**

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A Packomatic machine sends the "twenty-mule team" on its way faster . . .

At Pacific Coast Borax Company, the Telescoping Volumetric Filler automatically measures 8 and 16 ounces of "Boraxo" into metal containers at the rate of 120 units per minute.

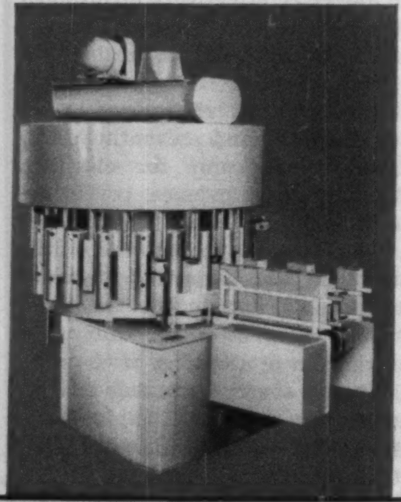
If you're a manufacturer of hard-to-handle dry products, write us about the Packomatic TVF and our dustless method of filling cartons or cans.

In fact, if *yours* is a problem of packaging — whatever the type, whatever your equipment budget — there's a Packomatic machine to save you time and money.

## TELESCOPING VOLUMETRIC FILLER

**A high-speed production machine, the TVF may be factory customized to fill up to 300 units per minute—round or rectangular cans or cartons. Its operation is practically dustless when handling such difficult products as insecticides, pancake flour, caustic soda, cleansers, detergents and soap powders. Phone collect, or write for literature about the economy, accuracy and speed of the PACKOMATIC TVF.**

**Other PACKOMATIC machines include the Bale Sealer — Case Sealers — Opener-Loaders — Case Imprinters — Telescoping Volumetric Filler — Packer-Gluers. Units available, semi-automatic or fully-automatic depending on your needs.**



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***Over 50 years' experience in Customized Packaging Equipment***

**J. L. FERGUSON CO.**
**Joliet, Illinois**

**New York, Chicago, Cleveland, Boston, Tampa, Baltimore, Portland, Denver, Los Angeles, San Francisco, Seattle, New Orleans, Louisville, Kansas City and all principal Canadian cities.**

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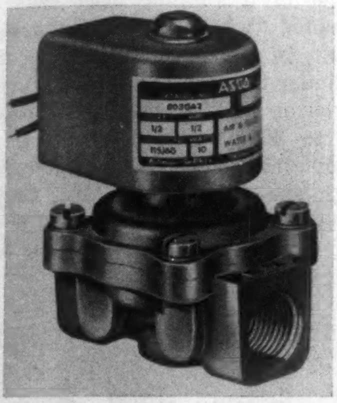
# AUTOMATION new components

Parts, elements and devices designed for creating more automatic systems

For detailed information and literature, use card page 17



## Solenoid Valve

Suitable for handling air, gas (manufactured and natural), propane, water, gasoline, light fuel oil, and other low viscosity fluids, Model 8030A solenoid valve is designed primarily as a gas pilot control valve for industrial power boilers. Tight seating valve is particularly useful for low pressure air and gas controls on gas fired ovens and furnaces, automatic dispensing units, vacuum holding applications and similar units.

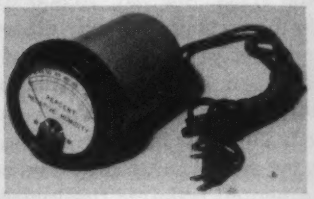
The direct lift solenoid operated valve has a heavy duty, forged brass body and bonnet, stainless steel spring and stainless steel core. The forged brass construction along with the stainless steel core and spring eliminate many corrosion problems. Oversize ports (⅝-inch orifice) are provided to assure greater flow at low pressure drop. The valve mounts in any position and the solenoid can rotate 360 degrees. **Automatic Switch Co.,** 391 Lakeside Ave., Orange, N. J.

*Circle 434 on Reply Card*

## Humidity Indicator

Designed for humidity chambers and process control panels, Model 102 panel hygrometer is an accurate instrument suitable for all industries concerned with measurement of relative humidity.

Heart of the Model 102 is the humidity sensing element, a specially treated plastic material which responds to changes in relative humidity in a logarithmic fashion. Unaffected by chemical vapors or high temperatures, the element features complete stability over extended periods of time without recalibration.



Easily mounted in a panel, Model 102 is available with or without external switches for changes in range calibration, single or double scale. The humidity sensing element can be placed behind the panel, or if desired, one or more elements can be remotely located.

The unit is actually a simple ac ohmmeter. In operation, a voltage is developed across the humidity sensing element which is rectified in a bridge circuit and applied to a sensitive meter. Calibration to a standard is effected by externally switching a calibrating resistor. **El-Tronics Inc.,** 1420 Walnut St., Philadelphia 2, Pa.

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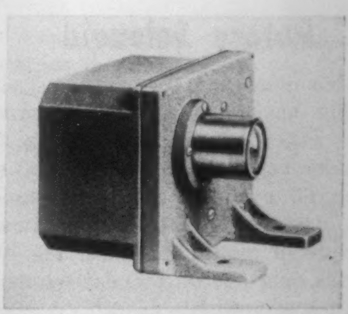

## Relay Combination

New control unit combines a photoelectric relay and a timing relay, both triggered by the same photoelectric element. The photoelectric relay energizes when the light beam is interrupted; the timing relay energizes when the timing period elapses while the light beam is interrupted. In automatic car wash applications, the photoelectric relay is used to operate the spray valve and the timing relay is used to operate an electric counter. The time delay prevents false counts due to momentary interruption of the light beam. In conveyor jam-up control combined with counting, the photoelectric relay actuates the counter; the timing relay operates the conveyor control. Each object that interrupts the light beam is counted. When an object obstructs the light beam beyond the timing period, the timing relay stops the conveyor. The photoelectric relay contacts are single-pole, double-throw, rated 5 amp at 115 v ac, noninductive load. The timing relay contacts are double-pole, double-throw, rated 8 amp at 115 v ac, noninductive load. **Autotron Co.,** Box 722-RR, Danville, Ill.

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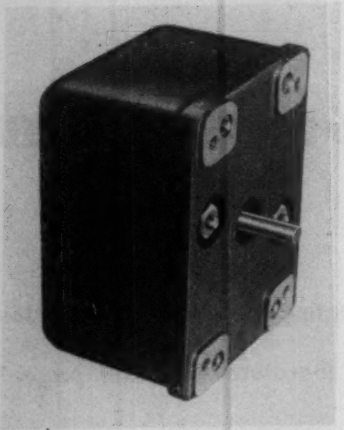

## AC Rotary Solenoid

Recommended for gaging, packaging, sorting, automatic assembly and other applications calling for precise repetitive operation, 400 series, 60 cycle ac rotary solenoids are designed to provide maximum torque in minimum space. The 400 series operates on standard voltage with low power consumption. Continuous and intermittent duty types are available, offering 20, 30, 45 or 60-degree maximum rotation. Typical intermittent duty model offers 12 inch-lb torque at 115 v. The solenoid closes in approximately 0.020 seconds. Totally enclosed, the unit offers complete environmental protection. **Leetronics Inc., Dept. A-2,** 30 Main St., Brooklyn 1, N. Y.

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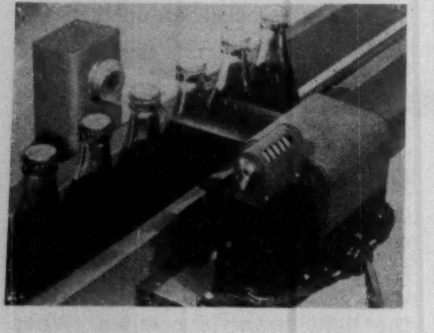

## Photoelectric Control

Called the PE-150, new photoelectric control unit features simple, plug-in installation. The light source unit directs the light beam into the photoelectric tube. Any object can be made to cut off the light beam — even freshly painted parts, or parts so delicate that mechanical fingers cannot be used. Properly placed controls can separate objects according to height. Reflected light may be used to identify light and dark objects. The contacts control 10 amp at 110 v ac, 60 cycle, which is enough current to operate counters, magnetic relays, solenoids and many other magnetic devices. PE-150 units are housed in sturdy hammertone gray steel cases. **Ripley Co. Inc.,** Middletown, Conn.

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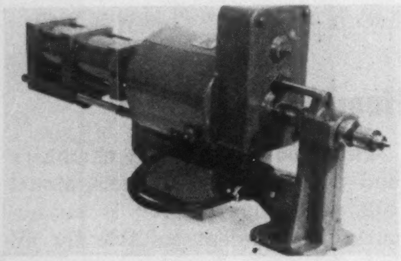

## Automatic Drillers

Addition to line of automatic drilling units, Model 113 has an electric motor driven spindle and hydraulically controlled, air operated quill feed. The spindle feed and speed are under separate control for any combination of feed to speed. An induction type motor with timing belts provides speeds from 865 to 13,800 rpm. A double-acting, 2-inch diameter air cylinder provides the thrust for drilling. An air line with approximately 40 to 80 lb pressure is required. Directly in back of the air cylinder, but separated by two seals and a vented relief, is the hydraulic system which controls the rate of travel. Oil flows from one side of a piston to the other through an adjustable needle valve. A bypass valve around the needle valve is provided so that rapid advance to the work can be had. For close depth tolerance, a threaded positive mechanical depth stop is provided. In setting up a job, this is first adjusted for the desired spindle travel. The limit switch provided is then set to trip a few thousandths before. The overtravel of the air cylinder, while the valve is reversing, will allow the quill to bottom on the positive stop and precise depth control can be attained. **Electro-Mechano Co.,** 261 E. Erie St., Milwaukee, Wis.

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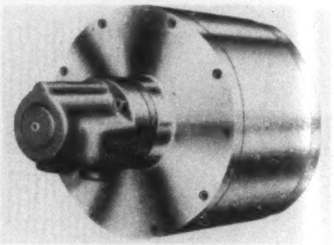

## Rotating Cylinder

In line with the trend to hydraulic operation of machine tools and other machines, new rotating hydraulic cylinder provides greater force in a smaller area than is possible with an air cylinder. Built in various bore sizes, the cylinder is rated for use with pressures up to 750 psi and at speeds up to 3000 rpm. Cylinder is of alloy iron and is balanced for high speed use. **S-P Mfg. Corp.,** 12415 Euclid Ave., Cleveland 6, O.

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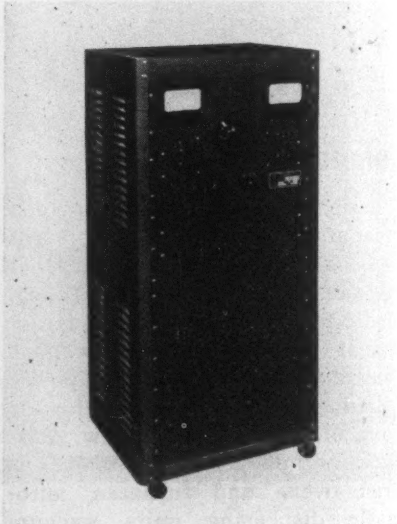

## Magnetic Amplifier

Designed for research and development laboratories, continuously variable magnetic amplifier power supply has many other uses in any application calling for continuously variable power outputs. Design features of this Model EM-117 power supply include: No moving parts, no filaments, and no maintenance. Critical tolerance engineering of the unit provides high overload capacity, eliminates warm-up time and insures long life. Unit utilizes an input voltage of 105 to 125 v ac, 55 to 65 cycles, single-phase, and produces a continuously variable output of 2 to 300 v dc, 0 to 5 amp with a regulation of 1 per cent or better. Ripple is 0.2 per cent rms with recovery time of 0.2 second. All power supplies are equipped with 4-inch rectangular voltmeter and ammeter. Power supply is available in standard size of 18 inches deep by 22 inches wide by 48 inches high; other sizes can be supplied to meet particular requirements. **Engineered Magnetics Co.**, 11818 Teale St., Culver City, Calif.

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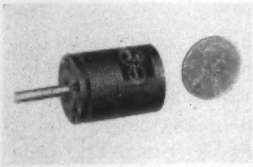

## Tiny Motor Gear Head

Designed for adaptation to Size 8 motors, ultraminiature motor gear head weighs just 1⅛ oz. Unit measures 0.750 inch in diameter and in the solid type model is 1 inch long. Four through-bolts make it adaptable to specially tapped Size 8 motors without the use of adapter plates or other accessories, thereby eliminating extra weight and removing another variable from the electromechanical assembly using it. Assembly operations may also be simplified when the direct mounting method can be employed. Class 5 ball bearings throughout contribute to the unit's low starting torque of 0.004 inch-oz. Ratios up to 650:1 are available in the unit with no increase in length; ratios up to 20,000:1 can be produced in longer units. Motor gear head is designed to operate synchro and potentiometer type loads. Applications include missile control systems, where weight, performance and size are critical; servomechanisms; aircraft control equipment; indicating devices; computers and other precision electromechanical instruments. **Bowmar Instrument Corp.**, 2607 Pennsylvania St., Fort Wayne, Ind.

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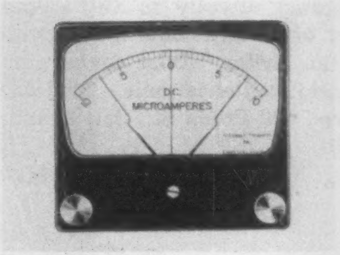

## Contact Meter-Relay

New indicating meters with built-in relay contacts have automatic or manual reset. One contact is carried on the moving element of the meter; the other on a semifixed pointer which can be rotated about the same axis as the moving element. The indicating meter part is similar to conventional D'Arsonval type meters. A moving coil, with pointer, is pivoted on jewels and rotated in the flux gap of a permanent magnet. The torque of the moving coil is so low that it cannot be depended on for reliable contact operation. To overcome this, a locking coil, integral with the moving element, develops additional torque to drive the contacts together with a pressure of 1 to 3 gm. When the meter pointer and contact setting pointer meet, the contacts close and lock because the current carried by the contacts flows through the locking coil. Reset consists of opening locking circuit. Spring action in the contact kicks them apart. The contact setting is adjustable to any point on the meter scale. **Assembly Products Inc.**, Chesterland, O.

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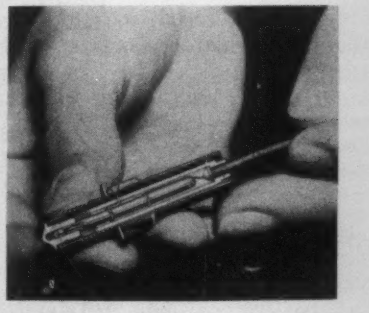

## Overheat Warning Control

Used for airplanes, industrial machine bearings and other equipment where an accurate overheat warning signal is needed, new bearing overheat detector thermostat is a miniature control weighing only 1 oz. Mercury contact thermostat inside the metal housing detects a bearing overheat temperature of 275F and lights a warning signal in less than 4 seconds from the time the overheat condition takes place. No amplifier, relays or bridge pickup box are needed to work with the miniature control, which may be supplied with Vapor themostats of any temperature setting up to 550F. Thermal switch may be installed easily by threading it into a ⅜-inch tap in the housing of various types of bearings that need to be protected. One electrical contact is grounded to the metal housing of the control; the other is a copper lead with teflon glass fiber insulation. **Vapor Heating Corp.**, Dept. PR56, 80 E. Jackson, Chicago 4, Ill.

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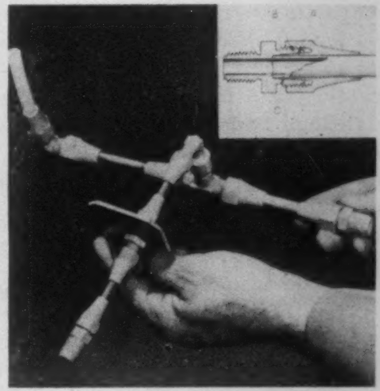

## Nylon Fitting

Called the Zytel (Dupont nylon resin) Miracle Fitting, new device is designed in only two pieces. The fitting is a time-saver because no flaring of tubing or exact tube length is required. There is no stripping of threads and every joint is a union. The fitting has a temperature range from −70 to 295F, and has a positive leakproof and vibrationproof seal which will withstand pressure up to 500 psi. It has the corrosive resistance of stainless steel, making it impervious to most acids and alkalis; the fitting is guaranteed not to crack or leak under normal conditions. The device is available in sizes from 1/16 to ½-inch in all variations. **Jaco Mfg. Co.**, P. O. Box 2659, Cleveland 7, O.

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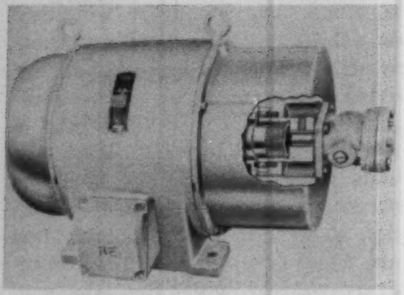

## Hydraulic Pump Motor

New spline coupling method of hooking up a hydraulic pump to an electric motor's output shaft eliminates adapter and alignment problems. Time required for installation is approximately one-tenth as long as conventional hookups. Other features of the motor include: Streamlined appearance since the entire hookup is enclosed in the motor's end bell; spline coupling supplied with the motor; compactness—new 30 hp unit is 2½ inches shorter than the previous 15 hp unit. Spline-coupled hydraulic pump motors are available in ratings from 15 through 40 hp in frame sizes 325U and 326U, and are supplied for either single or double-end pump installations. **Reuland Electric Co.,** Alhambra, Calif.

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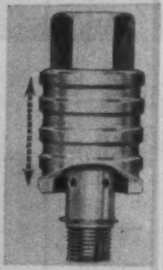

## Three-Way Sleeve Valve

Developed for the control of clamp type and other single-acting spring return cylinders, new inline, three-way valve, Model 600, is actuated by a sliding sleeve. In downstream position, air flows through to the cylinder; in upstream position, inlet air is cut off and exhaust ports opened. An extension on the sleeve deflects exhaust air to protect operator from air blast, blown chips or dirt.

Available in ⅛, ¼ and ⅜-inch NPT sizes, the valve may be mounted directly in the cylinder port or at any convenient location in the airline. Inlet connection is female; outlet is male. **Modernair Corp.,** 400 Preda St., San Leandro, Calif.

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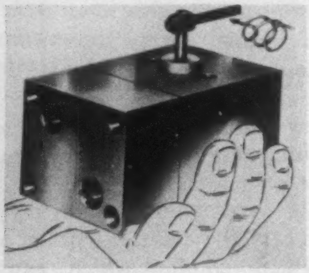
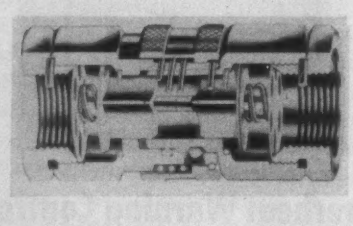


## Hydraulic Relay

High precision tool which is capable of a high frequency response, new hydraulic relay is available to original equipment market users as a control component or, it can be used for—or will be furnished with—complete signal systems, pump units and accessories for specific automatic control applications such as web guide, speed, pressure, flow, voltage, current and position. The relay is applicable in many phases of automation. It may be installed in any position and requires no adjustment. The standard unit may be operated at hydraulic pressures to 750 psi without the use of auxiliary devices. Any metering device that produces a signal force in the magnitude of a few grams, and is proportional to deviation, makes the relay a powerful automatic hydraulic control for the metered circumstance. **Hague Regulator Corp.,** Orangeville, O.

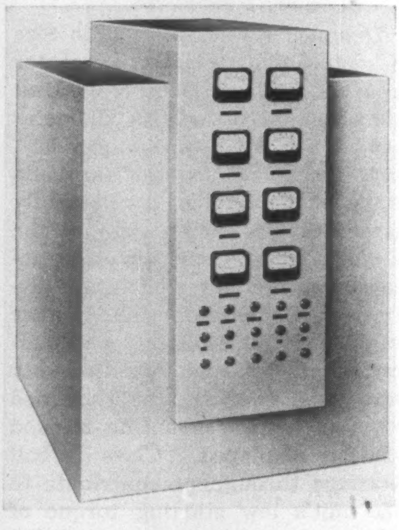
*Circle 448 on Reply Card*



## Fluid Transfer Coupling

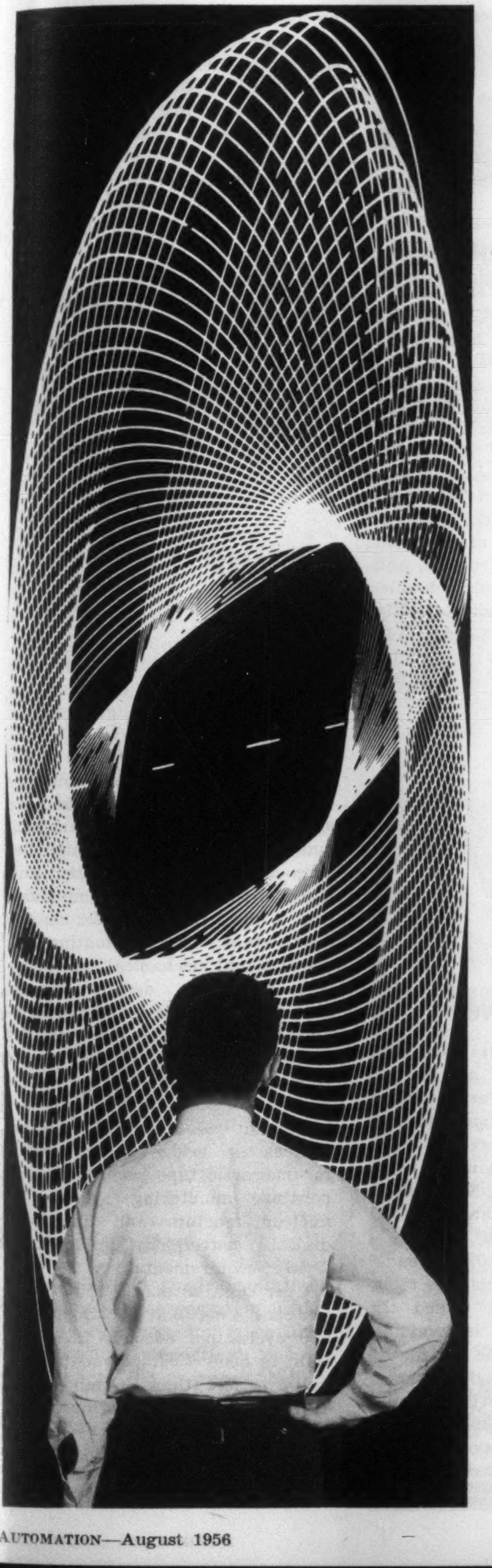
New quick connect-disconnect coupling for acids, alkali, solvents, high pressure steam—previously impossible fluid transfer—is known as the HK coupling. Its use is limited only by the ability of its teflon nipple seals and valve seals, for which there is no known solvent. The HK will function through a temperature range of −100 to 500F and can be subjected to lower and higher temperatures for short periods. The coupling can be furnished in 303 and 316 stainless steels, brass, aluminum, special carbon steel, or from any machinable material. Coupling is available without valves, or with automatic shut-off valves incorporated in either or both ends, causing the valved end of the line to shut off immediately and automatically upon disconnection. When connected, the coupling valves automatically open. The coupling is available in ½ through 3-inch inside diameter pipe sizes with any type end connection desired. **Snap-Tite Inc.,** Union City, Pa.

*Circle 449 on Reply Card*



## Control System

Designed for specific control of a product, process or machine, control systems are available for completely explosion proof operation as well as for dust tight, water tight, drip proof or regular commercial use. Each system is compactly built and features improved circuitry specifically designed to maintain reliability. Typical uses of the control systems include: Magnetic stirrer controls, electric wire annealing and sintering fur-



## *as an Autonetics Engineer... you can achieve science-fact far stranger than science-fiction*

Today at AUTONETICS there are elaborate automatic control systems actually being developed, designed and *produced* in quantity that make the mechanics of the wildest space fantasies look ordinary.

For example, where in the pages of science-fiction is there a robot that compares with AUTONETICS' new airborne digital computer? This 3-cubic-foot brain can solve mathematical problems in one second that would take a math whiz with pencil and paper 9 hours, or require a clothes closet full of ordinary computer equipment. It can continuously integrate 93 quantities simultaneously . . . through 51 removable panels of etched, transistorized circuitry.

This is only one example of AUTONETICS' far-reaching electro-mechanical technology. There are hundreds of other areas of equally advanced opportunity in missile guidance, flight control, fire control and special automatic controls. Among your tools are the latest data processing equipment, plus modern and complete environmental and flight test facilities. AUTONETICS' scientific leadership is setting the pace in this field with its unique 10-year backlog of know-how.

**OPPORTUNITIES FOR:**

**Computer Specialists**
**Electro-Mechanical Designers**
**Environmental Test Engineers**
**Electronic Component Evaluators**
**Instrumentation Engineers**
**Fire Control Systems Engineers**
**Flight Control Systems Engineers**
**Electronics Research Specialists**
**Computer Programmers**
**Computer Application Engineers**
**Automatic Controls Engineers**
**Electronic Engineering Writers**
**Inertial Instrument Development Engineers**
**Preliminary Analysis and Design Engineers**
**Also Openings for Draftsmen and Technicians**

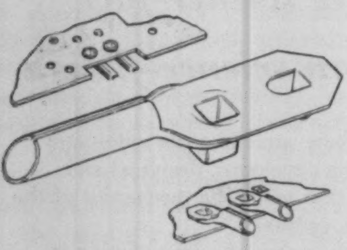
**CONTACT: Mr. R. C. Smith, AUTONETICS Engineering Personnel Office, Dept. 991-20 AUT, P. O. Box AN, Bellflower, Calif.**

**Autonetics**

A DIVISION OF NORTH AMERICAN AVIATION, INC.

AUTOMATIC CONTROLS MAN HAS NEVER BUILT BEFORE nace panel systems, plastic machinery, oven and machine tool controls, sulfite liquor waste evaporator and reactor thermal systems panel boards, ammonia dissociator control units, automatic operation of autoclaves and feed control stations, sequencing, warning and annunciator systems. Illustration shows control system designed for automatic operation of multiple lock tab carton packager. **Devco Engineering Inc.,** Dept. 270, P. O. Box 387, Caldwell, N. J.

*Circle 450 on Reply Card*



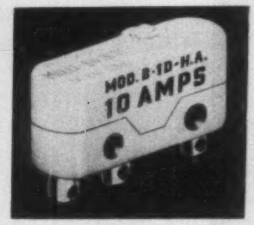
## Interlock Terminals

Used for small or large mechanized production line assembly operations, line of interlock terminals is available in loose or chain form. Primarily designed for use as an ac interlock, the terminals are equally adaptable for connecting speaker leads, printed circuit panels or flybacks and also as mounting lugs on transformers for printed circuit applications.

Design features include: Reinforced ribs to prevent bending or deformation of any part of the terminal during continuous use; bullet shaped male prong for easy and quick insertion into line cord female; and square extruded barrel and inverted tongue which assure proper alignment and accurate spacing when terminals are used in multiples.

Automatic application of the interlock terminals is accomplished with the Malco interlock lugging machine. Suited for small or large operations, its rate of production is variable. A feature of the machine is the ease and flexibility which it provides in changing over from one board size to another. Terminals are fed in tandem, singly or in multiples, at each stroke of the machine. **Malco Tool & Mfg. Co.,** Dept. ANC, 4025 W. Lake St., Chicago 24, Ill.

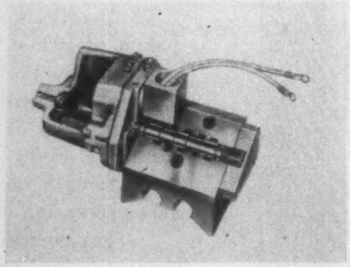
*Circle 451 on Reply Card*



## Subminiature Switch

Featuring reliability and maintenance of definite operating characteristics, subminiature snap-action switch, Model No. B-1-H.A. is rated at 10 amp at 30 v dc resistive or 8 amp at 30 v dc inductive. The tiny switch also features maximum movement differential of 0.0015-inch, 0.008-inch pretravel, temperature range of −67 to 300F and excellent operating force differential. The switch is of patented one-piece spring construction, and is furnished single-pole, double-throw, with one circuit normally closed. **Milli-Switch Corp.,** 1742 Berkeley St., Santa Monica, Calif.

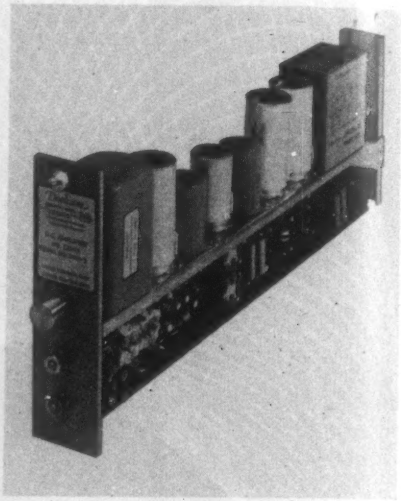
*Circle 452 on Reply Card*



## Air and Oil Valve

More than 100 model variations for a wide range of air and oil pressure applications are provided by basic design of multipurpose valve. The valve, for example, can be easily adapted to power a welding gun, air operated transfer mechanisms, air riveting and testing fixtures. The unit completes a valve cycle within 0.033 seconds; it is engineered and built to tolerances of 0.0001-inch. Called the Comet II, the valve is available with ¼ or ⅜-inch pipe tap for inline, manifold or base mounted; in single-solenoid spring return, double-solenoid momentary and double-solenoid three-position. The solenoid direct operated, four-way spool type valve arrangements can be used for straightway or three-way functions by plugging ports. Compactly designed, the valve measures only 3½ by 3⅞ by 7¼ inches. Flow capacity is equal to ¼-inch diameter hole. **Ross Operating Valve Co.,** 120 E. Golden Gate, Detroit, Mich.

*Circle 453 on Reply Card*



## DC Amplifier

Designed to serve as a low level preamplifier in data handling systems where millivolt signals must be amplified with a high degree of linearity, stability and speed of response, new dc amplifier uses a magnetic converter as the input stage. By eliminating the conventional mechanical type chopper, this new design concept achieves a new level of performance and at the same time provides complete isolation of the input from amplifier chassis and circuit ground. Typical applications are multipoint scanning of thermocouples or bridge measurements for magnetic tape recording, temperature monitoring system for nuclear reactors and analog-to-digital conversion preamplifier. Power requirements are 300v dc ±1 per cent, 20 ma; −150v dc ±1 per cent, 8 ma; 6.3v dc ±5 per cent, 400 cycles per second, 1.35 amp. Gain is 5000 ±0.3 per cent. Stability is less than 30 mu v zero drift. **Doelcam Div., Minneapolis-Honeywell Regulator Co.,** 1400 Soldiers Field Rd., Boston 35, Mass.

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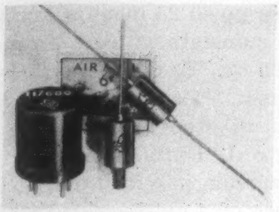

## Silicon Rectifiers

Designed for stable operation at high ambient temperatures (to 150C) and featuring high breakdown voltage (1500 v minimum), new silicon grown junction rectifiers are ideal for miniaturization purposes and will withstand extreme conditions of shock, vibration and humidity. Available in two types of axial and stud half-wave models and a full-wave plug-in model, hermetically sealed rectifiers eliminate the need for filament power. The axial models, 1N543 and 1N543A, allow point-to-point wiring; Types 1N544 and 1N544A are stud mounted for maximum heat dissipation. The plug-in model, TI/680, can be used in many applications to replace the JAN 6X4 rectifier tube. All rectifiers are heat cycled from −55 to 75C with 95 per cent humidity four times, and from −55 to 150C for four additional cycles to insure maximum reliability, stability and long life. **Texas Instruments Inc.,** 6000 Lemmon Ave., Dallas 9, Tex.

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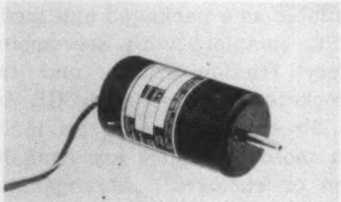

## AC Servomotor

Applicable in instrumentation, controlling and servosystem fields, 60-cycle ac servomotor is capable of producing intermittent output torque up to 8.0 oz-inches. Motor can be furnished as three, two or single-phase requiring a capacitor for starting and running. Induction motors can be furnished in three general torque classifica-

BOWSER ESTABLISHED 1885

CUTS COSTS 3 WAYS

METERING 1

Bowser meters with ticket printers provide accounting records of liquid receipts, transfers and deliveries.

CONTROLS INVENTORY

Perpetual inventory and accurate control of process liquids in plant pinpoints profitable operation.

FILTERING 2

Bowser filters of all types are available for filtration of nearly every process or industrial liquid.

IMPROVES QUALITY

Uniformity of color and clarity with better quality control assures efficient processing of finer end-products.

BLENDING 3

Bowser blenders proportion and combine any number of liquid components in a continuous, closed system with highest accuracy at pumping flow rates.

SAVES MAN-HOURS

Hand "batching" is eliminated. Push-button control automates production to cut costs, improve profits.

Write for "DIGEST"

Bowser "liquid automation" equipment is available on lease or progressive payments to conserve working capital.

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BOWSER NATIONWIDE SALES AND SERVICE

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BOWSER, INC., 1399 E. Creighton, Fort Wayne, Ind.

*Circle 580 on Inquiry Card*

Socket Slotted

SET SCREW

Application 7 Times Faster, New SETKO HOPPER-FED Way

One plant's production rate zoomed from 300 per hour to 2,000 per hour after installing Setko Hopper-Fed Special Equipment* which adapts readily to present machines. Others are making similar gains and getting many additional advantages such as great reduction in cross-threading and floor loss; adaptability to all metals or plastics and smaller set screw inventory.

Arrange for demonstration at our plant, without cost or obligation to you.

**Fill in coupon and mail today.**

*Pat. No. 2,638,945 Other Patents Pending

Set Screw & Mfg. Co.

266 Main St., Bartlett, Ill. (Chicago Suburb)

1160

We Specialize in Solving Puzzling Set Screw Problems

COUPON

SET SCREW & MFG. CO., 266 Main Street, Bartlett, Illinois

I would like to have free demonstration of Hopper-Fed Set Screw mechanism at your plant. Please advise particulars.

INDIV. NAME..........

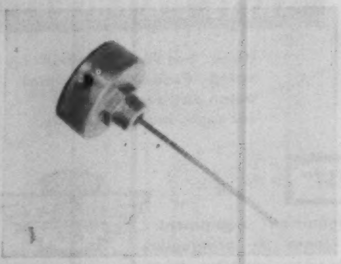
COMPANY..........

ADDRESS..........CITY..........ZONE....STATE..........

*Circle 581 on Inquiry Card*

tions: High pull out, low stall torque, used in blower applications; control motor torque characteristics, used as servomotors; and low pull out, high stall torque, used as intermittent duty power unit in actuators and also as variable frequency motors. Motors are designed for operation over an ambient temperature range from −65 to 71C. Special units can be furnished to operate in ambient temperature as high as 150C. **Globe Industries Inc.**, 1784 Stanley Ave., Dayton 4, O.

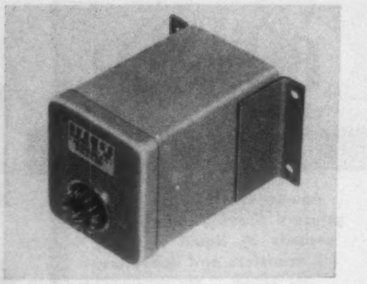
*Circle 456 on Reply Card*



## Bin Level Control

Designed to indicate and control level of all kinds of solid materials, new bin level control is called the Flextrol. It works well with all kinds of solids, coarse and fine, wet and dry, and is easily installed in the side or top of a bin, chute, or coal distributor, simply by providing a 1½-inch threaded connection in the wall. The Flextrol control consists of a dust tight aluminum housing, a sensitive electric snap switch and a stainless steel sensing rod, flexibly supported by a rubber disk. The rod is deflected by the material in the bin, and in turn, actuates the switch. The switch may be wired to operate a signal or other electrical device. The rubber disk which supports the rod provides a pressure-tight seal against the contents of the bin. There is no danger of loss through diaphragm failure. Action of the level control depends on a minute movement of the sensing rod which may be caused either by the normal flow of the material through a chute, hopper, etc., or by the compacting of the material when it is charged into a bin while the outlet is closed. **Eastern Products Co.**, P. O. Box 657, Westfield, N. J.

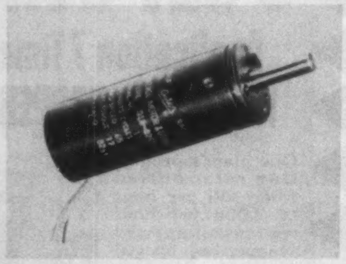
*Circle 457 on Reply Card*



## Telephone Type Relay

Designed for use where space economy is an important factor, hermetically sealed short form telephone type relay offers the advantages of the long form telephone relay armature, hinge and contact arms. It can be equipped with many special features including copper slugs for time delay, special contact materials and high voltage insulation. Series SE relay features dc operation, fast operate and fast release with a maximum of ten form *A* or six form *C* contacts. Relay has single or double-wound coils with resistance up to 38,000 ohm and single or double armature with a heavy duty armature hinge. It can be provided with creepage insulation and a plug-in or solder type header. **Kurman Electric Co. Inc.**, 35-18 37th St., Long Island City, N. Y.

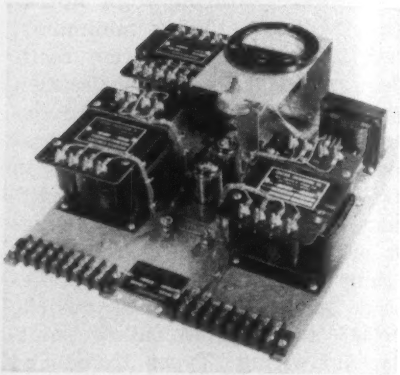
*Circle 458 on Reply Card*



## Servo Gear Train

Weighing only 6.875 oz and consisting of a single unit instead of two separate parts, size 11 servo gear train can be built to operate at 150C ambient. Both the motor section and the gear train section are versatile and are designed to cover a wide range of applications. Motor can be made to operate as a two, four, six or eight-pole unit. Windings can be made to operate on 60 or 400 cycle, 26 to 115 v. The gear train operates with load torques up to 25 inch-oz, and maximum momentary load torques of 75 inch-oz. Backlash is 35 minute minimum. Gear ratios may be varied in steps from 12 to 1 to 4000 to 1. Units have been made with windings to load output transformers of amplifiers or to be connected directly to the output tubes or transistors. **John Oster Mfg. Co., Avionic Div.**, Racine, Wis.

*Circle 459 on Reply Card*

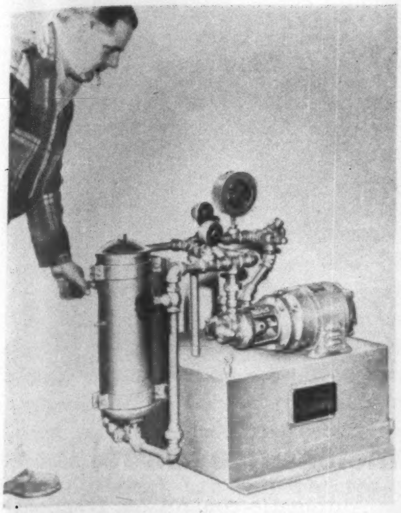


## Closed Loop Servosystem

Device which is called the LC Servo-Amp is designed for any application where an accurate, automatic correction is required as a result of a change in the load of a motor. Unit is essentially a closed loop servosystem arranged to maintain a constant, preselected pressure between parts and tool of machines such as in wire brushing, deburring, buffing, polishing, sanding, etc. The LC Servo-Amp is available as a packaged unit model LCSR complete with servomotor, safety friction clutch and two sprockets, and model LCCR for the direct operation of an induction motor. Models are available open or enclosed. Arrangements can be made for remote mounting of the indicating meter and auxiliary controls. The electronic portion may be supplied as an integral part of automatic sequencing control circuits.

Features of the servosystem are positive control and accuracy, adjustable sensitivity and low torque operation. Unit is calibrated in per cent load and is unaffected by temperature or vibration. **Control Engineering Co.**, 8900 Alpine Ave., Detroit 4, Mich.

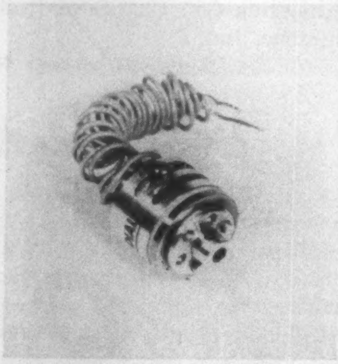
*Circle 460 on Reply Card*



## Lubrication Systems

Continuous recirculation of filtered oil to bearing surfaces is provided by circulating lubrication systems. Equipment consists of liquid pump, tank, filter, heat exchanger, control valve and necessary piping. Lubrication systems are used in the paper, rubber, textile, machine tool, metal rolling and associated industries. Since they prevent oil breakdown and the consequent development of sludge and harmful deposits, the systems provide important protection against costly downtime and expensive bearing repair or replacement. **Bowser Technical Refrigeration,** Terryville, Conn.

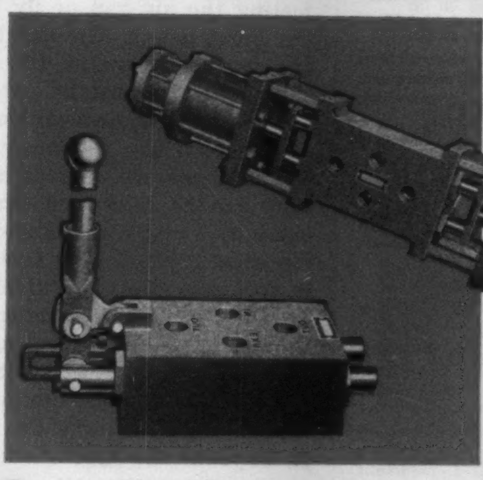
*Circle 461 on Reply Card*



## Tension Controller

Fixed or variable tension control for applications such as fine wire winding, film reeling and high speed thread winding is provided by tension control unit. It can also be used in mechanisms where max-

Quick-As-Wink®
HYDRAULIC VALVES



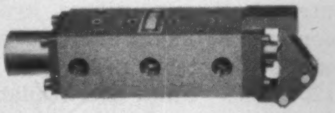
Double Pilot Cylinder Operated 3-position 4-way Hydraulic Valve

(At left) Lever Operated 3-position 4-way Hydraulic Valve

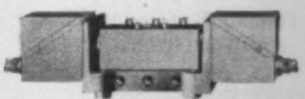
**Hand and Pilot-operated Types for water or hydraulic oils to 5000 psi.**

• These valves give users maximum efficiency, economy and dependability. Housings are milled from steel blocks or bronze forgings. The hollow, radially ported, stainless steel plungers are hard chrome plated and polished. Renewable metal valving rings assure long life of the packers which are expanded by internal pressure . . . the higher the pressure the tighter the seal. No metal to metal seating. The valves are fully balanced in any position. Inspection — and servicing if necessary — can be done easily *in the field,* avoiding the delays of returning valves to the factory for servicing, or the need to carry large inventories of standby valves — or even parts. Complete dimensions, capacities and other data sent promptly. Write for Bulletin No. 531,— Today!

Ask us also about . . .



CAM OPERATED SINGLE PLUNGER VALVE 3/8" to 3/4" sizes. Operated by rotating cam or land on reciprocating device.



DOUBLE SOLENOID "O-TYPE" VALVE for pressures up to 125 psi. Widely used as pilot valves and for operating air cylinders.

THE HIGHER THE PRESSURE THE TIGHTER THE SEAL

Quick-As-Wink®
AIR AND HYDRAULIC
Control Valves

*Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated*

*Mfd. by* C. B. HUNT & SON, INC., 2071 East Pershing St., Salem, Ohio

*Circle 582 on Inquiry Card*

NEW METER-RELAYS
**FROM 0-5 MICROAMPERES-UP**
Ruggedized - Sealed, Black Bakelite or Clear Plastic Cases

*D'Arsonval meters with locking contacts for sensitive and accurate control or alarm.*

TRIP POINT ADJUSTABLE to any point of scale arc. Sensitive to changes as little as 1%. One contact on moving pointer. The other on adjustable pointer. When pointers meet, contacts close and lock. Holding coil wound on moving coil. Locking is electro-magnetic. Manual or automatic reset. Spring action kicks contacts apart.

Model 461-C, 10-0-10 Ua DC **$83.25**

**Ranges:** From 0-5 microamperes, 0-5 millivolts or 0-300°F up.

**Standard Contact Rating** 5 to 25 milliamperes DC. Can be up to 100 milliamperes DC.

**Ruggedized-Sealed** metal cases, 2½", 3½" or 4½" round, shock-mounted movement, gasket-sealed.

**Black Bakelite** case, 4½" rectangular.

**Clear Plastic** cases, 2½", 3¾" or 4½" rectangular.

Panel meters and indicating pyrometers also in ruggedized-sealed, black bakelite or clear plastic cases. Write for new 40 page Catalog 4A on meter-relays, meters, pyrometers and automatic controls.

Model 255-C, 0-10 V DC **$42.50**

**Assembly Products, Inc., Chesterland 27, Ohio.** HAmilton 3-4436 (West Coast: Desert Hot Springs 27, Calif. Phone: 4-3133 & 4-2453).

(See us at Wescon Show, Aug. 21-24, Los Angeles

*Circle 583 on Inquiry Card*

**R E S U L T S !**

"We have received more response in the form of inquiries from our small advertisement in "Automation" than we have from other advertisements combined during an even longer period of time.

"This response is very much appreciated and serves to further compliment your fine publication."

Robert H. Ganz, Manager
GANZ BROTHERS, INC.

A recent survey indicates that twenty-one percent of the plants rated $1,000,000 or over plan to use the services of outside automation specialists.

**A card in AUTOMATION pays dividends.**

imum torque transmission must be accurately controlled. Range of the device is 0 to 50 oz-inches. Design of the tension control unit is based on the Dial electromagnetic clutch, which is converted to a tension unit at the factory by addition of the slip attachment "T." Control is sensitive and accurate, and a wide range of torque values can be set by the user, either by adjusting the air gap or by varying the input power. The slip between the two members of the unit is smooth and constant, absorbing and leveling out undesirable surges of power. Where a number of tension controls are used as a group, they can be controlled simultaneously by a single rheostat or other electrical control. Unit is available in two sizes: Size 100 which measures 1⅛ inches in diameter by approximately 1½ inches, and Size 130 which measures 1½ inches in diameter by approximately 2¾ inches. **Dial Products Co.,** 9 Ave. E, Bayonne, N. J.

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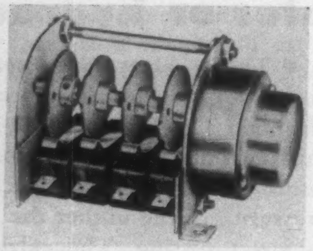

## Multicircuit Timers

Designed for applications such as appliance timers, vending machines, industrial controls and commercial controls, line of multicircuit, repeat cycle timers and interval timers utilizes synchronous timing motor and snap-action enclosed switches rated at 15 amp, 125 v ac. Units are available in various switch combinations and are normally made with preset factory adjusted cams and cam settings. Cam speeds are available in ranges from 1 rps down to 1 revolution per month. Illustrated unit is approximately 3 inches high by 2 inches wide, and with four switches, is approximately 4 inches long. **Bristol Motor Div., Vocaline Co. of America Inc.,** Old Saybrook, Conn.

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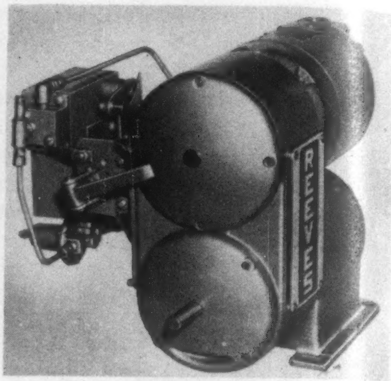
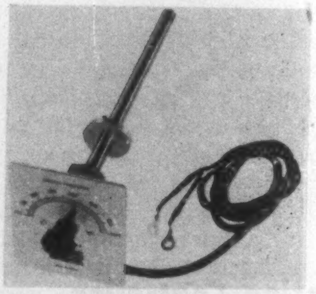


## Motor Drive Control

Automatic control for fractional series of motor drives is actuated from any pneumatic instrument that gives signals of 3 to 15 psi air pressure. The instrument operates an air piston through valving to control the lateral movement of the speed changing mechanism, and in turn the output of the variable speed drive. Principal use of the control is in continuous processing applications where the drive speed is required to automatically vary in accordance with changes in liquid level, pressure, temperature, flow, weight, position, color, etc. A compensating feature has been built into the controller to secure a true linear relation between changes in input air pressure and variable output speed. This factor is important in obtaining accurate speed control in many automatic control systems. **Reeves Div., Reliance Electric & Engineering Co.,** 1225 Seventh St., Columbus, Ind.

*Circle 464 on Reply Card*



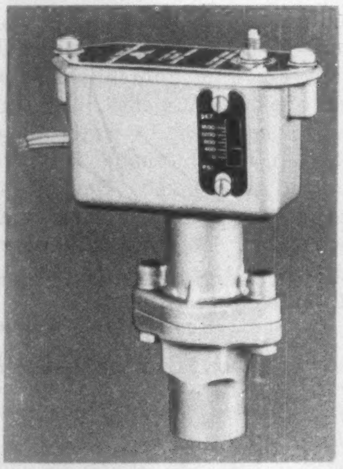
## Two-Range Thermostat

Used for heat holding or as an automatic shutoff device when connected to a relay, adjustable high temperature thermostat has two operating ranges. One range is from 600 to 1900F; the other (for special applications) is from 600 to 2400F.

Thermostat consists of a sensing tube approximately 10½ inches long, with a sensitive area of approximately 5 inches. This sensing tube is connected to a limit switch rated at 15 amp, 125v ac. A control panel with a pointer and scale showing the complete range of the thermostat is linked to the limit switch. Expansion and contraction of an Inconel tube in relation to an enclosed porcelain rod operates the plunger of the limit switch, which can be connected to a relay for applications requiring more current.

Temperature sensing element is completely mechanical and not affected by vibration, voltage fluctuations or stray magnetic fields. **Franklin Dales Co.,** Dept. 4B, 180 E. Mill St., Akron, O.

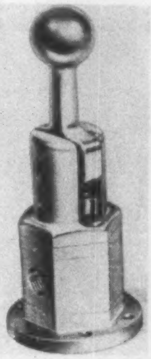
*Circle 465 on Reply Card*



## Pressure Switch

Accurate sensing of any system pressure over an adjustable range of 15 to 3000 psi is possible with new pressure switch. Unit features a calibrated plate which enables setting the switch before or after installation on a pressure line. Tamperproof indicator inside the switch is visible through a window in the plate. By means of an external adjustment screw, indicator can be lined up with the desired pressure on the plate. Once this pressure is set, screw can be locked in place to avoid accidental disturbance. Fixed actuation value of the switch varies from 10 to 250 psi depending on switch setting. Piston type sensing element will perform millions of cycles under fast, continuous operation, and is insensitive to jarring or vibration. Switch has adaptable mounting bracket which may be rotated to any position on a full circle or moved up and down on the neck of the switch. **Barksdale Valves,** 5125 Alcoa Ave., Los Angeles 58, Calif.

*Circle 466 on Reply Card*



## Pilot Valves

Hand, foot, palmbutton, cam and solenoid actuated models are available in new line of pilot valves. Provided in a variety of mountings, the new valves can be installed almost anywhere — convenient to hand or foot, or overhead out of the way. They can be located on the equipment or remotely installed.

Hand valve is available in either locking or nonlocking type. Valve may be used singly or in series for working pressures up to 150 psi. The foot valve has generous treadle area and can be anchored in position easily.

The palmbutton valve is especially suitable for panel mounting. The valve returns to normal position when the button is released. The solenoid valve, with instantaneous action, has a cover which offers full protection against dust and dirt, and is easily and quickly removed without tools. The cam valve features a built-in overtravel which prevents damage when a series of cams operate the valve. **Mechanical Air Controls Inc.,** 10030 Capital, Oak Park, Detroit 37, Mich.

*Circle 467 on Reply Card*

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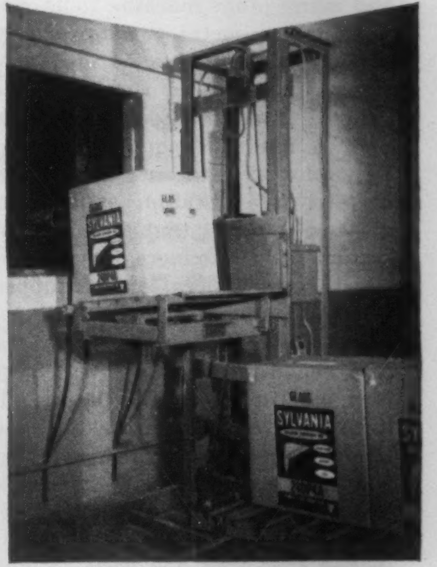
**Weld-Bilt**

**AUTOMATIC CONVEYOR-LIFT ELEVATORS**



Here's the modern way to transfer conveyor loads from one level to another . . . A "Weld-Bilt" Elevator lifts or lowers packages or parts to any level on one-floor line, automatically selecting certain packages, passing others, without manual attention! Adjustable tilting platforms, product-operated switches, continuous operation, with automatic "traffic-jamb" stops. Designed in any capacity, any height, with controls to handle any situation.

Write for "Weld-Bilt" suggestions to help move your conveyor lines more efficiently.

**"Weld-Bilt" PRODUCTS**

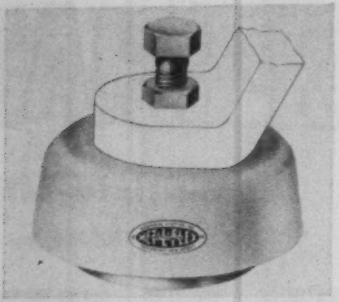
*Weld-Bilt Automatic Conveyor-Lift or Floor-to-Floor Elevators, Portable Elevators, Lift Trucks, Hydraulic Lift Tables, Pallet Trucks, Drum Elevators, Skid Platforms, Special Equipment.*

**WEST BEND EQUIPMENT CORPORATION**

*MATERIALS HANDLING ENGINEERS*

347 WATER STREET • WEST BEND, WISCONSIN

*Circle 584 on Inquiry Card*



## Machinery Mount

Engineered for protection against vibration and the control of shock for such machines as presses, grinders, millers, lathes and many other machine tools, adjustable, all-metal machinery mount has an increased load carrying capacity in three models ranging from 1000 to 10,000 lb per unit. A natural frequency of 7 to 10 cycles per second makes absorption of vibration shock and noise so complete that punch presses and drop hammers may be located near offices or on upper floors. Stainless steel resilient elements offer maximum damping plus long life resistance, with performance that is unaffected by oil, water, solvents, dust or extreme temperatures. A built-in leveling bolt and jam nut allow for quick installation on uneven floors. Maximum stability of the mounts eliminates the need for lagging the machine to the floor, so that mobility becomes an added feature. **Robinson Aviation Inc.,** Teterboro, N. J.

*Circle 468 on Reply Card*

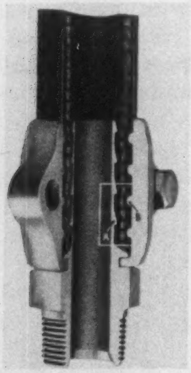
DIGITAL VOLTMETER
+5023

## Digital Voltmeter

Featuring automatic and continuous calibration, four-digit digital voltmeter has one-digit accuracy and 0.01 per cent stability. Called the Model 1040, this instrument has a voltage range of 0.001 to 999.9 v. Input impedance is 1000 megohms on 9.999 scale and 11 megohms on other scales. Polarity and range switching are also continuous and automatic.

Instrument features digital, inline readout, which may be remoted or miniaturized. Voltmeter operates on 115 v, 60 cycle, 80 w. **Electro Instruments Inc.,** 3794 Rosencrans St., San Diego 10, Calif.

*Circle 469 on Reply Card*

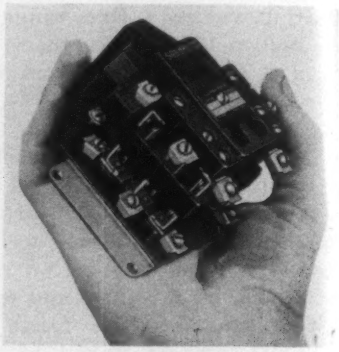


## Hose Fitting

Designed for use by manufacturers of equipment for road building, farm machinery, oil field, heavy construction, railway, mining and all heavy duty equipment using hose assemblies, clamp coupling has grip features obtained by positive positioning of machined insert and clamp. This positive positioning is obtained as the outside rib of the clamp is locked between the collar and hex of the insert before tightening. Accurate location of the clamp over the insert assures alternate mating of the barbs of the insert with the ribs of the clamp. Machining of these ribs and barbs permits the hose to be uniformly compressed into each alternating recess, which multiplies the holding power. Longer service is assured because hose and wire are not pinched or weakened. Beveled shoulder of barbs permits easy insertion of device into hose.

Fitting is for low, medium and high pressure hose up to 5000 psi working pressure. Clamps are available for hose sizes ranging from 1/4 to 2 inches inside diameter, according to pressure requirements. **Eastman Mfg. Co.,** Manitowoc, Wis.

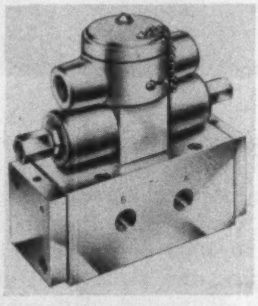
*Circle 470 on Reply Card*



## Machine Tool Relay

Companion device to the two-pole Type DO-22 relay, new four-pole machine tool relay is identified as Class 8501 Type DO-42 and measures only 2 13/16 inches wide by 3 11/16 inches high. The two versions (both 10 amp, 600 v) will handle most relay applications. For mounting convenience and easy substitution when more poles are required, both relays have identical baseplates and can be mounted interchangeably. Balanced construction minimizes wear on a single moving part. Plastic impregnated molded coil is unbreakable, operates cooler, is dimensionally stable and impenetrable by water and oil. All contacts are visible for inspection and maintenance. Device can be completely disassembled in a few seconds by loosening two screws. **Square D Co.,** 4041 N. Richards St., Milwaukee 12, Wis.

*Circle 471 on Reply Card*

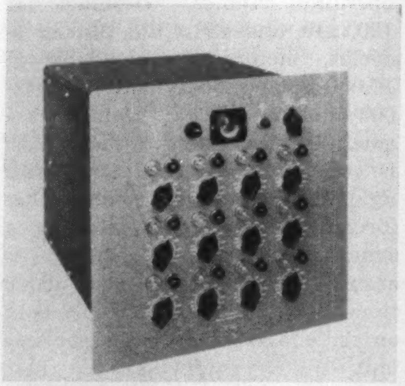


## Control Valves

Designed for controlling air cylinders and other air-operated devices, series of solenoid and master air valves are used for three and four-way air operation up to 250 psi, and are available in sizes of 1/4, 3/8, 1/2, 3/4 and 1 inch. Dependable service is assured by seals which eliminate damage from external grit and moisture. Bubble-tight aluminum spool is sealed positively by O-rings.

Valves will operate when surrounding temperatures are as low as −40F provided the air is free from freezing moisture. For protection, the solenoid coils are encased in covers. When covers are removed, the valve is inoperative. An optional safety feature, the manual override, allows equipment to be tested before final electrical installations are made, and also provides a method for operating the valve in case of electrical failure. Valves have a built-in junction box which may be rotated 90 degrees for convenient piping of conduit. **Hanna Engineering Works,** 1765 Elston Ave., Chicago 22, Ill.

*Circle 472 on Reply Card*



## Conductivity Bridge

Designed for multipoint testing setups usually requiring a duplication of indicating and control equipment, new instrument includes a bridge controller and indicator, programmed switching device, and suitable relays for operation of control equipment. With this equipment, it is possible to monitor and control the conductivity at up to 12 points of measurement. Different concentrations can be maintained at each of the 12 test points by means of a conductivity knob and dial for each position. If any of the monitoring points deviate from these set concentrations, alarm and/or corrective action is automatically put into effect. Each test point is monitored for approximately 10 seconds. If corrective action or

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with stationary ring cover, for heavy-duty, large production runs

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For light assembly operations using Selective Parts Feeders to feed component parts

**BARREL FEEDER**
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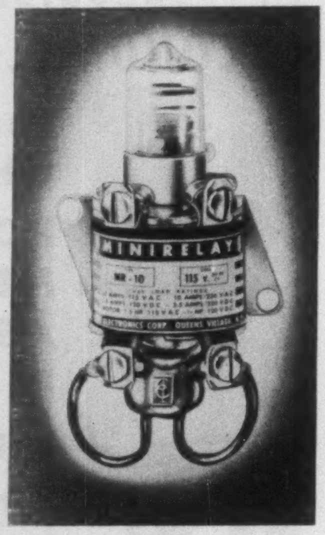
alarm is required for longer than this time, such action continues until the condition corrects itself. Model ARPT-12 is used in both the electrical and solution conductivity field. **Industrial Instruments Inc.**, 89 Commerce Rd., Cedar Grove, N. J.

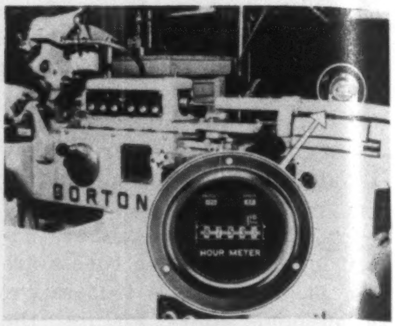
*Circle 473 on Reply Card*



## Plunger Type Relay

Designed for use in the electronic, electrical and appliance industries, mercury plunger relay is capable of handling any load up to 20 amp or 1.5 hp at 115 v, 50 to 60 cycles. Some typical control applications of the relay are in automation equipment, furnaces, ovens, motor and valve operation. Called the Minirelay, the device has a fast action of approximately 30 milliseconds to make or break. Minirelay has been proved for use in motor, general purpose and tungsten lamp applications at full load for many operations. Measuring only 3½ inches high by 1¾ inches wide by 1½ inches deep, the relay has been designed for compact multiple arrangements. Relay's mercury-to-mercury contacts are totally enclosed in hermetically sealed, heavy industrial glass for safe, silent operation even in explosive, dusty, moist or dirty atmospheres where open-type mechanical relays are inadvisable. **Ebert Electronics Corp.**, 212-26N Jamaica Ave., Queens Village 28, N. Y.

*Circle 474 on Reply Card*



## Hour Meters

Used to record the operating time of automatic machines, power conveyors, packaging machines, compressors, punch presses, motor generating sets, pumps and refrigeration units, ac meters are addition to line of electrical timing instruments. Information obtained is of value in protective maintenance programs and production operation studies. Designed for 120, 240, and 480 v, 25, 50 and 60 cycles, meters are available in 10,000-hour models and in 100,000-hour models. Instruments are small in size, and the mechanism is completely enclosed and sealed against dust, moisture and other foreign matter. Powered by a synchronous motor, accuracy is assured, and total accumulated time is registered and easily read on the odometer. Any ac powered unit can be equipped with these instruments. **John W. Hobbs Corp., Div., Stewart-Warner Corp.**, Springfield, Ill.

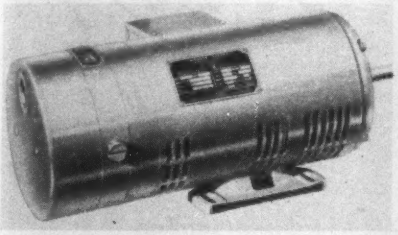
*Circle 475 on Reply Card*

## Electronic Timers

Good repetitive accuracy of the timed impulse is provided by two new general purpose electronic timers. Model TA-1 is enclosed in a housing suitable for mounting in the open; TA-2 is a chassis model designed for use in conjunction with other electrical equipment. Both operate within the ranges of 0.05 to 1 second, and 0.05 to 10 seconds. The units operate without warmup, being operative as soon as power is applied. The time control adjustor which is fitted with a scale calibrated for 0 to 100 reads approximately in percentage of the full range of the timer. Remote adjustment of the

unit is affected by removing the time control adjustor from the timer chassis and operating it from the remote position. Only two tubes are used in the timer—a voltage regulator and a cold cathode trigger tube. The circuitry of the device is arranged so that the trigger tube conducts only an instant at the end of the timed impulse, thus prolonging tube life. **Post Machinery Corp., Electronic Products Div.,** Beverly, Mass.

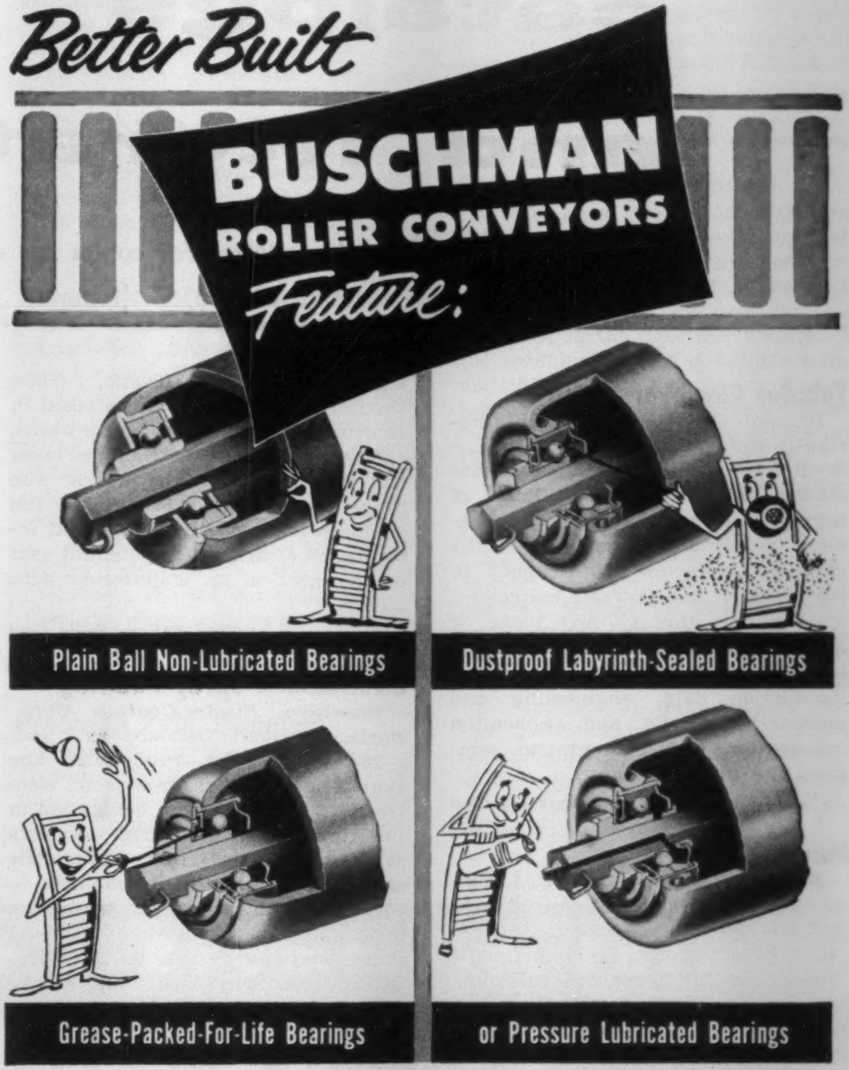
*Circle 476 on Reply Card*



## Fractional HP Drive

An adjustable speed drive designed to meet the need for fast stopping or cycling operations, new single-package unit is an integral combination of ac constant speed induction motor, eddy current coupling, friction brake and electronic control. A connection to a standard power line is the only wiring required. All drives have a continuous constant torque rating through a 25 to 1 speed range. Electronic control insures speed stability of ±2 per cent of top speed at any point within the operating range. **Dynamatic Div., Eaton Mfg. Co.,** Kenosha, Wis.

*Circle 477 on Reply Card*



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**ROLLER CONVEYORS**
*Feature:*

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Grease-Packed-For-Life Bearings

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In roller conveyors, it's the bearing that counts! And BUSCHMAN conveyors use only performance-proven bearings... engineered for long life and trouble-free operation in every type of service. No matter what normal operating conditions may be, BUSCHMAN has a conveyor pre-engineered to meet your needs.

Conveyors are available with various types of rollers and frames, in different sizes and spacings, and in any width from 6 inches on up. BUSCHMAN can supply 45° and 90° curved sections, switches, spurs, work stations and other components to provide a complete, efficient materials handling system.

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# catalogs and literature

Latest automation information. For copies use card page 17.

## Tubular Conveyors

*Hapman Conveyors Inc., Div., Hapman-Dutton Co., Kalamazoo, Mich.—36-page catalog*—Fourteen actual case studies illustrating applications of conveyors to solve a variety of handling problems are included in the catalog. Conveyors are designed to move almost any flowable material—wet or dry—through any plane or angle. Weight-volume-time conversion chart, conveyor capacities chart, installation data, engineering and mechanical details, and application information and photographs comprise the catalog.

**Circle 478 on Reply Card**

## Magnetic Tapes

*Minnesota Mining & Mfg. Co., Dept. A6-114, St. Paul, Minn.—12-page bulletin*—Physical and magnetic properties of 12 Scotch brand magnetic tapes used for numerous recording applications are given in illustrated booklet. Cellulose acetate base tapes used for high fidelity audio recordings, polyester base tapes which offer more recording time and cellulose acetate base magnetic film for motion picture sound recording are among the types discussed.

**Circle 479 on Reply Card**

## Industrial Rotary Pumps

*Tuthill Pump Co., 939 E. 95th St., Chicago 19, Ill.—8-page bulletin*—Designed for service on compressors, engines and power units, machine tools, oil burning equipment, speed reducers and special machinery, line of positive displacement, internal-gear rotary pumps is the subject of Catalog No. 100. Cutaway drawings illustrate pumping principle; pump guide lists models and gives the type of service, operating data, packing, mountings and features of each model.

**Circle 480 on Reply Card**

## Heat Processing

*Lanly Co., 750 Prospect Ave., Cleveland 15, O.—8-page bulletin*—Line of equipment designed for heat processing in the fields of ceramics, chemicals, metals, paints, plastic, rubber, textiles and varnishes is described in Bulletin 560. Monorail conveyor ovens, cabinet type ovens, batch type, cross bar conveyor and continuous web ovens are illustrated. Features of the equipment are discussed; general information of interest to potential user is presented in an engineering data section.

**Circle 481 on Reply Card**

## Electrostatic Spray Painting

*Ransburg Electro-Coating Corp., Barth & Sanders, Indianapolis 7, Ind.—16-page booklet*—Production line examples of No. 2 Process of electrostatic spray painting being used in the finishing of industrial products ranging in size from automobile chassis and refrigerator cabinets to toy automobiles and door knobs are included in new booklet. Triple-head units, stationary disk and reciprocating atomizing disk units are illustrated.

**Circle 482 on Reply Card**

## Automatic Process Controls

*Mason-Neilan Regulator Co., 1190 Adams St., Boston 24, Mass.—16-page booklet*—Pressure regulating valves, controllers, recorders, valve positioners, air operated control valves and liquid level controllers are among the equipment designed for automatic control which is discussed in catalog No. 54. Arranged according to function of the instrument, the bulletin includes photographs, specifications, application data and operating information.

**Circle 483 on Reply Card**

## Thermistor Applications

*Victory Engineering Corp., 93 Springfield Rd., Union, N. J.—20-page booklet*—Sixth edition of booklet describing thermistors, varistors and assemblies includes technical data and illustrations of devices. Electrical and physical characteristics and uses of bead, disk, rod and washer type thermistors, and of thermistor hypodermic needles, combustion analyzers, gas analysis cells, etc. are included.

**Circle 484 on Reply Card**

## Subminiature Switches

*Microswitch, Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.—16-page booklet*—Total of 56 different switches, auxiliary actuators and switch assemblies are covered in Catalog 75A. Data on completely sealed environment free subminiature switches and actuators, illuminated pushbutton assemblies, light force pushbutton switches and a new series of sealed, multicircuit toggle switch assemblies are included.

**Circle 485 on Reply Card**

## Meter and Transmitter

*Askania Regulator Co., 240 E. Ontario St., Chicago 11, Ill.—8-page bulletin*—Positive displacement type flow meter and a pneumatic signal transmitter comprise the Transometer, the subject of Bulletin 301. Diagrams illustrate how the device is used for flow, ratio and combustion control; for multiple fuel totalization; and for interchangeable control in fuel switchover. Ranges, specifications and operating information are also included.

**Circle 486 on Reply Card**

## Zero-Leakage Sealing

*Franklin C. Wolfe Co., 3644 Eastham Drive, Culver City, Calif.—9-page bulletin*—Hypothetical case is used to illustrate cost of zero-leakage sealing by gasket, O-ring in-groove, and Gask O Seal methods. Points of cost which are covered are original cost, preparation cost, cost of installation, anticipated service, cost of replacement part, and cost of replacing part. Necessity of zero-leakage sealing for both safety and economy reasons in the automation and instrumentation fields is discussed.

**Circle 487 on Reply Card**

## Motor Control Centers

*Federal Pacific Electric Co., 50 Paris St., Newark 1, N. J.—28-page catalog* — Designed for industrial, laboratory and commercial applications, plug-in type motor control units, are described in catalog. Construction details of control units and vertical sections are illustrated; components, including motor starters and industrial AB circuit breakers are covered; simplified removal of the units is shown.

**Circle 488 on Reply Card**

### Handling and Feeding Equipment

*F. J. Littell Machine Co., 4127 N. Ravenswood Ave., Chicago 13, Ill.*—28-*page handbook*—Designed to acquaint the reader with the line of coil stock handling and punch press feeding equipment, new catalog describes 24 bulletins on company equipment. Automatic roll feeds, feeding and straightening machines, spindle reels, scrap winders, cradle reels, cradle loading ramps, double cone reels, sheeting lines, oilers, and coil loading hooks are covered in the bulletins listed.

**Circle 489 on Reply Card**

### Differential Refractometer

*Barnes Engineering Co., Stamford, Conn.*—8-*page bulletin*—Used for the continuous measurement of refractive index in the process or pilot plant, differential refractometer is the subject of illustrated bulletin. Principles of refractometry, features, applications and specifications of the three available models are included.

**Circle 490 on Reply Card**

### Welding Automation

*Acro Welder Mfg. Co., 1719 W. St. Paul Ave., Milwaukee 3, Wis.*—12-*page bulletin*—Automatic operation and specially designed work positioning fixtures are features of line of resistance and arc welding equipment described in Bulletin 156. Photographs illustrate numerous applications of single and multihead welders.

**Circle 491 on Reply Card**

### Automatic Screw Machines

*Gear Grinding Machine Co., 3901 Christopher, Detroit 11, Mich.*—16-*page booklet*—Single-spindle bar automatic screw machines are described in illustrated booklet. Components of the machine, such as the cross and vertical slide, turret slide assembly, automatic forced lubrication and coolant unit are pictured and briefly described. Slotting and back drilling attachments and transfer mechanism for the machine are also discussed, along with its general specifications.

**Circle 492 on Reply Card**

### Precision Potentiometers

*General Controls Co., Skokie, Ill.*—12-*page bulletin*—Rotary, linear, multiturn and sector type potentiometers which translate rotary and linear mechanical motion to electrical signals are described in bulletin. Potentiometers are used for the precise control of electrical voltages and currents. Specifications, photographs and dimensional sketches of 12 models are included.

**Circle 493 on Reply Card**

### Package Tying Machine

*B. H. Bunn Co., 7605 Vincennes Ave., Chicago 20, Ill.*—8-*page bulletin*—Any package, regardless of its shape, that can be tied by hand, is automatically tied by new machine described in the bulletin. Feature of the machine is that it adjusts automatically to handle packages of varying sizes and shapes. Nine available models for different applications are illustrated and briefly described.

**Circle 494 on Reply Card**

### Continuous Oxygen Analyzer

*Hays Corp., Michigan City, Ind.*—16-*page booklet*—Used for flue gas analysis, process and product control and safety applications, magnetic oxygen analyzer and recorder device is the subject of booklet 55-829-56. Unit consists of an analyzing section electrically connected to a remote recording section. Special models, such as explosion proof analyzer, differential analyzer and mobile analyzer and recorder, are described.

**Circle 495 on Reply Card**

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## CATALOGS AND LITERATURE

### Power Transmission Equipment

*Lovejoy Flexible Coupling Co., Dept. ANC, 4800 W. Lake St., Chicago 44, Ill.—12-page bulletin*—Flexible couplings, variable speed pulleys and transmissions, universal joints and motor bases are included in line of power transmission equipment covered in bulletin. Photographs, specifications and operating data on various sizes and types of equipment are included.

**Circle 496 on Reply Card**

### Presses and Accessories

*Danly Machine Specialties Inc., 2100 S. Laramie Ave., Chicago 50, Ill. — 28-page catalog* — Rotary cam limit switch which is designed to time the cycling of feeding devices, unloading devices, die lifters and other automatic materials handling equipment, is one of the press accessories discussed in new catalog. Double action presses which range from 200 to 2000-ton capacity are illustrated. Other accessory equipment covered are built-in timing controls, adjustable press control arm, die area lighting, pressure control manifold, etc.

**Circle 497 on Reply Card**

### Welding Machines

*Taylor-Winfield Corp., Warren, O. —12-page bulletin*—High production of welded assemblies is possible with Geneva index dial feed machines described in Bulletin 8-213. Twenty-eight different models are illustrated with their production, operation, production rate and description given. Illustration of the Geneva index mechanism is also included.

**Circle 498 on Reply Card**

### Remote Metering and Control

*BIF Industries Inc., 345 Harris Ave., Providence, R. I.—8-page bulletin*—Chronoflo telemeters which provide remote metering of flow, level, pressure, temperature, gate position, and weight; and control of pumps, chemical feeders, valves and levels are the subject of Bulletin 230-H4A. Photographs of several models and application information are included.

**Circle 499 on Reply Card**

### Centrifugal Pumps

*Allen-Sherman-Hoff Co., 259 E. Lancaster Ave., Wynnewood, Pa.—12-page bulletin*—Line of Hydroseal pumps which are designed for pumping mixtures of solid materials in liquid at high efficiency is the subject of Data Sheet Pa. Pumps, which are used for hydraulic ash handling systems, are described with photographs, schematics and line drawings. Tables giving pumping capacities and related data are also included.

**Circle 500 on Reply Card**

### Thermocouple Circuit Restorer

*Peerless Electric Co., Electronics Div., W. Market St., Warren, O.—8-page bulletin*—Device used to renew proper electrical conductivity through thermocouples and thermocouple circuits used in heat treating, melting and other processing operations, is the subject of Catalog R-26. Diagrams, installation photographs and recorder chart reproductions illustrate how the unit monitors couples and thermocouple circuits transmitting emf to temperature indicators, recorders and controllers.

**Circle 501 on Reply Card**

### Automatic Valves

*P-K Industries Inc., 27 Porete Ave., N. Arlington, N. J.—22-page booklet*—Line of valves designed for high capacity and erosion resistance is described in booklet. Among types covered are automatic control valves, high pressure valves, blowdown valves, blowoff valves, etc. Specifications, operating characteristics and application data of the numerous models are included.

**Circle 502 on Reply Card**

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- Ideal for automation as well as conventional mass-production assembly lines!

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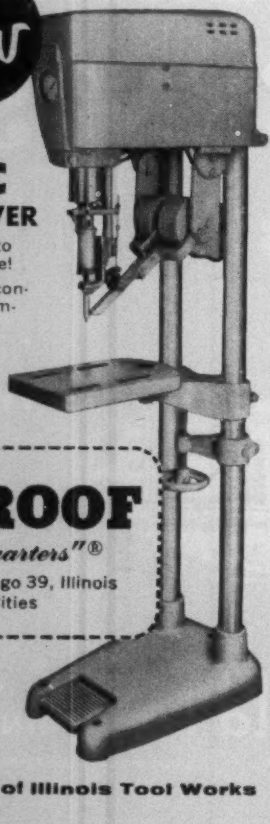

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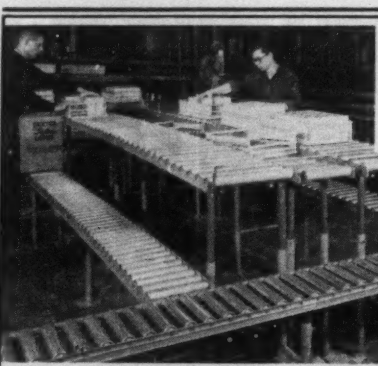

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### Continuous Metalworking

*Herr Equipment Corp., Warren, O.—6-page pamphlet*—Line of equipment including coil cars, rotating feed, pay-off reels, automatic stitcher, press feeds, slitters, bridles, levelers, shears, coiling reels, etc. is described in Bulletin No. 561. Equipment is used for continuous processing lines, punch and shear lines.

**Circle 503 on Reply Card**

### Photoelectric Pyrometer

*Photoswitch Div., Electronics Corp. of America, Cambridge 42, Mass.—4-page pamphlet*—Automatic temperature control is provided by photoelectric pyrometer which consists of a photoelectric scanner and a control unit. Pamphlet describes the device and lists some typical applications which include induction heating, forging, welding operations, continuous brazing and plant laboratories.

**Circle 504 on Reply Card**

### Automatic Measuring Machine

*Warner & Swasey Research Corp., 34 W. 33rd. St., New York, N. Y.—6-page pamphlet*—Automatic inspection gage for small to medium large quantities which is called the Probomat is the subject of illustrated pamphlet. Discussion of the operating characteristics, component parts of the device, and application information are included.

**Circle 505 on Reply Card**

### Air Operated Devices

*Gardner-Denver, Keller Tool Div., Grand Haven, Mich.—4-page pamphlet*—No. 9 issue of "Production and Plant Ideals" includes application information on automatic machine to form brazing rings on the job, Air-feedtapper, and axial piston air motor. Photographs and brief description of the operating characteristics of the devices are given.

**Circle 506 on Reply Card**

### Pressure Test Equipment

*Modern Industrial Engineering Co., 14230 Birwood Ave., Detroit 38, Mich.—4-page pamphlet*—Standard and special purpose test machines for automotive, appliance, aircraft and farm equipment industries are described in Bulletin PT-1. Several of the machines covered are designed for inclusion in automation lines. Eight different testers are illustrated and briefly described.

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### Rotating Components

*Precision Components Div., Norden-Ketay Corp., 555 Broadway, New York 12, N. Y.—4-page pamphlet*—Induction motors, tachometer generators, transmitters, receivers, two-phase servomotors, control transformers and resolvers are included in line of rotating components described in Bulletin 376. Characteristics of more than 138 rotating components are given.

**Circle 508 on Reply Card**

### Germanium Rectifiers

*Hanson-Van Winkle-Munning Co., Church St., Matawan, N. J.—4-page pamphlet*—Designed for low voltage, high current rectification, line of germanium rectifiers is described and illustrated in Bulletin GR-100. Rectifiers were designed for the electroplating industry, and are available in self-contained and remote control models.

**Circle 509 on Reply Card**

### Automatic Packaging

*Pak-Rapid Inc., Elizabeth St., W Conshohocken, Pa.—4-page pamphlet*—Variety of packaging equipment illustrated in pamphlet includes unit with magazine feed for identical circular shapes, conveyor feed for handling irregular long items, hopper feed for all types of screws and metal parts, and tray conveyor feed for assortment of small parts. Features of the equipment are briefly discussed.

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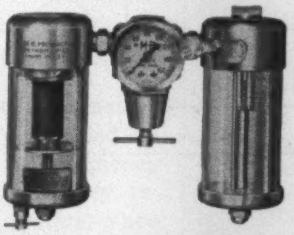

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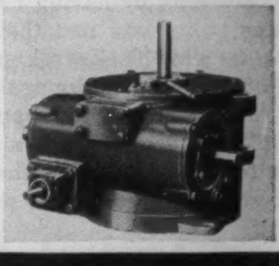

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## AUTOMATION abstracts

# TESTING HYDRAULIC SPEED CONTROL

By R. E. DAVIS and N. J. NITKA
Chief Project Engineer and Engineer
The Oilgear Co.

CLOSED LOOP hydraulic feedback drives give very accurate speed control. Measurement of the performance of such control systems demands precision measuring techniques. The measuring equipment should provide both measurement of steady state system accuracy and also transient and frequency response data. Frequency response and transient response give data useful in verifying theoretical system analysis and information telling how rapidly the system corrects for error-producing changes.

We will use a closed loop hydraulic tachometer feedback speed control system from the paper industry to demonstrate the procedures used in measuring the performance of a typical system. *Fig.* 1 illustrates such a system schematically; the system consists of a hydraulic transmission with a master hydraulic tachometer which gives the speed command, and a feedback tachometer coupled to the output shaft which feeds back a flow signal proportional to output speed. The pump flow is regulated by moving a slide block. The slide block motion is produced in the closed loop by having one tachometer pump into and the other out of the slide block stroking cylinder. This cylinder works against a half area piston on the opposite side of the slide block and also against a force produced by the pumping reaction forces of the pump.

### Steady State Error Measurement

To measure the steady state error of the system, we can use two synchros feeding into a differential synchro. Each synchro produces an output voltage proportional to its angular position. The two synchros are connected into the differential synchro in such a way that their voltages subtract; the difference in voltage produces a rotation of the differential synchro which is equal to the difference in rotations of the synchros. Thus the angular velocity of the differential synchro is an accurate measure of the difference in velocities of the two synchros. One synchro is coupled to the master tachometer shaft, the other to the feedback tachometer shaft; the differential synchro velocity is then a measure of the output shaft velocity referenced to a constant input speed. For a high-accuracy speed control system as we have here, timing a revolution of the differential synchro using a stop watch gives an accurate measure of steady state speed error.

An equally adaptable method for measuring small speed differences in synchronized shafts, again using time measurement, is that using a gated electronic counter. In this arrangement an electronic counter's pulse counting interval is determined by the master tachometer and the output shaft is used to give a relatively large number of pulses for the timer to count. Signals to the timer can be by phototube pickup, magnetic pickup, or some similar arrangement.

To get some idea of the order of magnitude of the measurements involved, we will consider the measurement of the maximum error of the hydraulic feedback system. A laboratory system uses a pump of 20 cu in per revolution

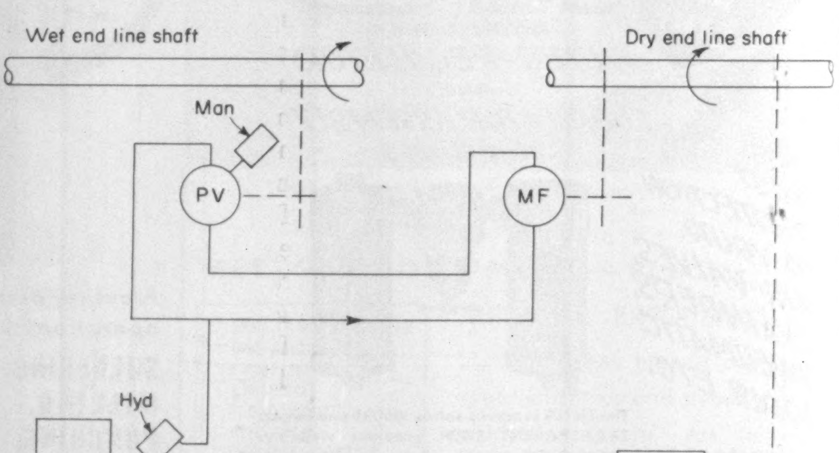


Fig. 1—Single section feedback drive. The *PV* notation indicates a pump, single, variable displacement, and *MF* indicates a motor, rotary, fixed displacement.

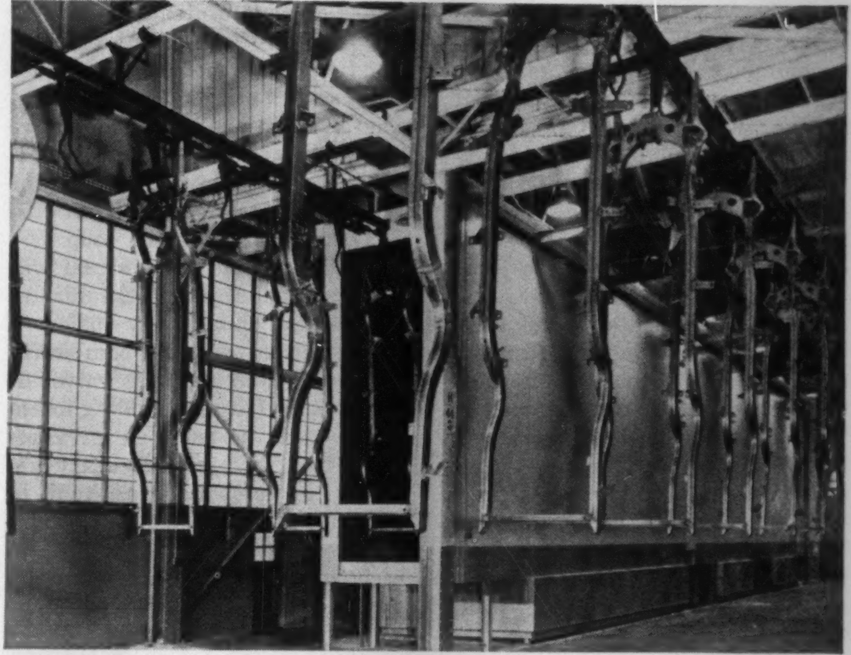
displacement driving a hydraulic motor of 7.5 cu in per revolution displacement. It will be interesting to compare a computed maximum error with the experimental error.

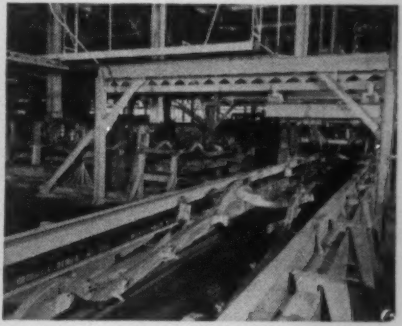
The error is introduced into the system by variation in stroking force of the slide block. This force variation causes a control cylinder pressure variation which produces a change in slip flow of the tachometer pumps. The slip variation must show up as shaft speed change. In simplified linear theory, the slide block control force is represented by a spring force directly proportional to eccentricity. Using a spring force of 3200 lb per in obtained from an auxiliary test of the pump characteristics, the variation in force on the slide block in moving 0.75-inch from full stroke to reverse full stroke gives a corresponding pressure variation of 90 psi on a 26.5 square inch stroke piston. Tachometer slip admittance, from an auxiliary test of tachometer slip, is 13 cu in per 1000 psi. These figures give a computed flow error of 1.17 cu in per min corresponding to 4.0 rpm for the 0.29-cu in per revolution displacement tachomoters. Percentage wise, the computed speed error is 0.17-per cent of maximum speed of 2300 rpm.

The measured maximum errors were in the order of 0.20-per cent of maximum speed of 2300 rpm for a reversing drive. The linear theory does not take into account system nonlinearities; probably the most important one here is the large coulomb friction of the slide block.

### Frequency Response Measurements

Probably the most illuminating measurement to be performed on the system is that of frequency response. Accurate frequency response curves for the system, when correctly interpreted, can give the mathematical analog of the system from which can be obtained the degree of stability of the system and its response to any form of input or load change. In our study of the laboratory drive, we predicted response of the system using a much simplified linear system as a mathematical analog.





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The experimental frequency response data was then used to determine how close the actual drive system response agreed with that of the simplified analog. Agreement proved quite favorable.

To perform a frequency response measurement of any system, we must apply a sine wave variation of variable frequency to the input and measure the amplitude and phase of the resultant sine wave output. The frequency response measurements should preferably be made on the open loop system. This is accomplished by removing the feedback loop. In the drive system we tested, it was not practical to open the loop because of the character of the input and feedback signals. (If the feedback flow is removed, the input flow immediately saturates the system.) We therefore measured a closed loop frequency response. These data can easily be transformed mathematically to the open loop curve by the relation $G(j\omega) = 1/[1+(1/M(j\omega))]$ where $M(j\omega)$ is the vector of closed loop response and $G(j\omega)$ that of the open loop.

The input sine wave signal was produced by stroking the master tachometer sinusoidally using a motor driven eccentric cam working on a small stroking valve. It is essential that the stroking mechanism used in such an arrangement have a high frequency response in comparison to that of the drive system tested.

Output speed was recorded on oscillograph equipment using a potentiometer coupled to the output shaft of the differential synchro; this gives a voltage proportional to differential synchro position. The differential speed is then the derivative of the recorded wave. To record the phase of the output referenced to the input, an event mark per input sine cycle is produced by incorporating a limit switch on the sine actuator. The event marks show up as pulses on the oscillograph tape.

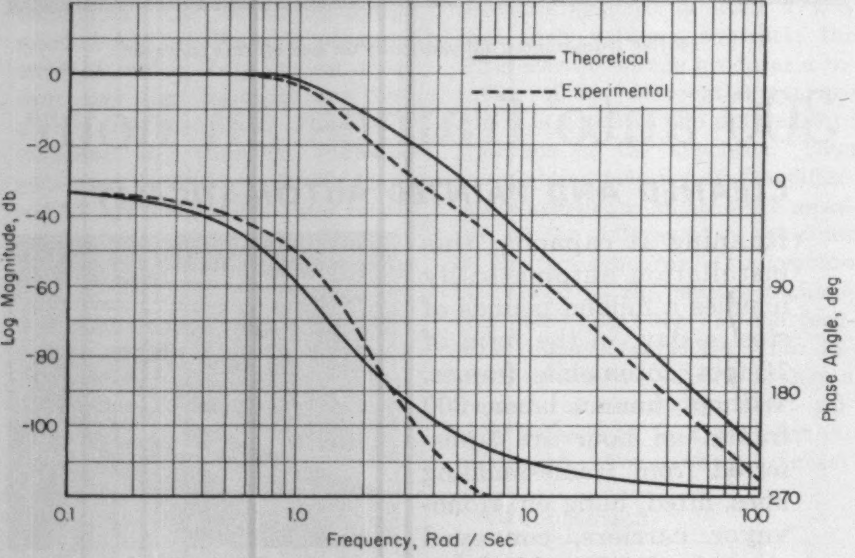

Fig. 2—Frequency response curves for laboratory drive.

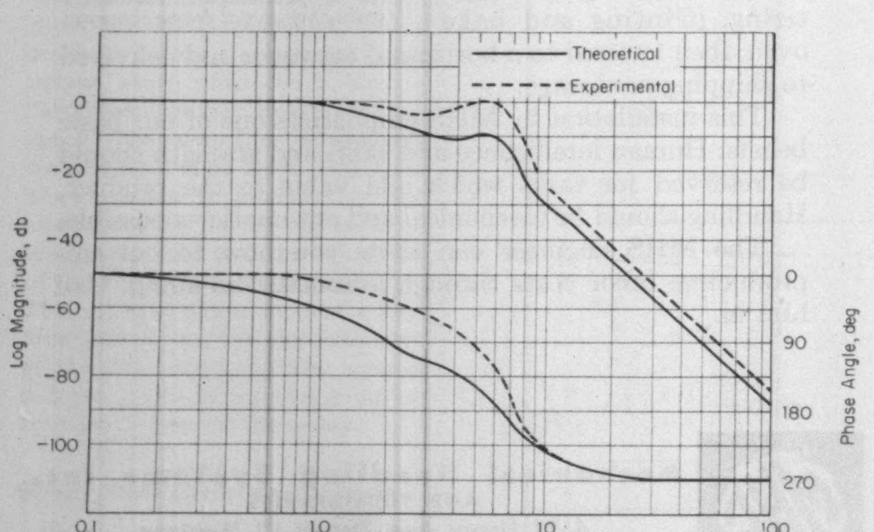

Fig. 3—Frequency response curves for 8 horsepower drive.

Output speed can also be measured using a dc tachometer generator to drive the oscillograph equipment. With this arrangement, it is usually preferable to drive the measuring tachometer at the surface speed of a relatively large cylinder on the output shaft or through a gearing arrangement in order to get sufficient output voltage from the tachometer.

For low frequency input sine waves, the closed loop output is identical to input both in amplitude and phase. This proves very convenient because the output measurement at low frequency input can be used as a measure of the input driving signal. The frequency response measurement is then conveniently performed by merely setting up the measuring equipment to measure output magnitude and phase and then running a continuous oscillograph tape while adjusting the input frequency. Care must be taken that input magnitude and phase are not changed as frequency is changed, and that sufficient time is allowed after each frequency adjustment to allow for the frequency changing transient to subside. In our laboratory setup the frequency response data were taken by adjusting the speed of the sine generator stroking motor in steps of speed, while the oscillograph was recording the output sine wave.

*Fig.* 2 shows frequency response curves for the laboratory drive tested. The theoretically predicted curves are also shown. *Fig.* 3 shows similar results for an eight horsepower drive in the field. The curves show that the predicted results agree very well with experimental curves.

Besides output measurements it is advantageous to measure the response at intermediate points within the system. This gives frequency response curves for the basic blocks of the system and can usually isolate the discrepancies between theoretical and experimental results. Response of intermediate blocks is straightforward when open loop data are being measured; however, the calculations are somewhat cumbersome when the loop is closed. When working with the closed loop, error signals must be computed and used as the input at each block; this is because the driving force for intermediate components is not the input alone but is also affected by the output feedback signal.

Pressure cells which use a strain gage bridge are available to transduce pressure signals to recordable voltage signals. Such a cell piped into the pump control chamber when provided with suitable amplifications of the voltage signal will give an oscillograph recording of the sinusoidal control pressure. This output measurement when compared with tachometer speed difference gives the response of the tachometer pump units and control piston loaded by the slide block. The frequency response curve for this unit can be plotted and compared with predicted response.

The pump slide block has a small translatory motion. An oscillograph recording of this motion can be obtained by mechanically coupling a linear translatory potentiometer to the slide block. This is easily done by providing a spring loaded rod to bear against a plane surface of the slide block. The potentiometer is provided with a convenient well filtered and regulated dc voltage, and the output is amplified through dc amplifiers to drive the oscillograph pen. A linear differential transformer may be substituted for the translatory potentiometer.

Pressure cells at the motor can be used to give a dynamic recording of the load-motor driving force.

### Transient Response Measurements

From theoretical equations for open loop frequency response of a linear system, response to transient changes can be determined. The reverse is also true; frequency response can be determined from transient response to suitable functions, although this is not as straightforward a problem. Measured transient response can thus serve as a check on the frequency response data; or, transient response data may be used as a measure of a system in place of frequency response.

The most convenient transient input to study is the step function of input which is a sudden change from one steady state condition of input to another steady state value. To measure step response of a system we must record the magnitude of the output or controlled variable just after we switch the input or reference variable from one value to another.

In studying our laboratory drive, we coupled the voltage signal from the potentiometer on the differential synchro to the oscillograph equipment just as we had done for the frequency response test. The reference or master shaft was driven by a small hydraulic transmission lightly loaded by the input

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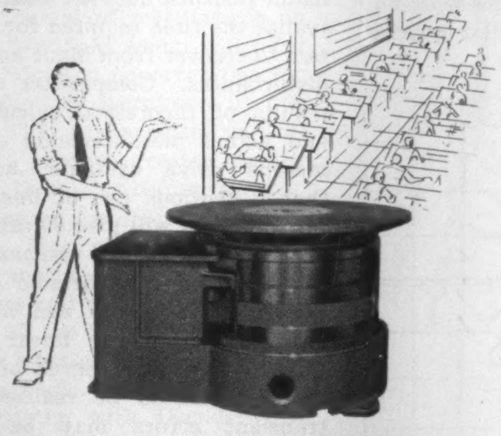

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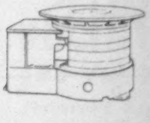

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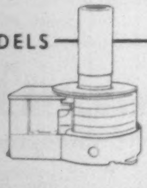

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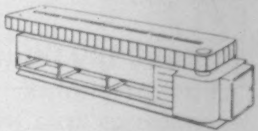

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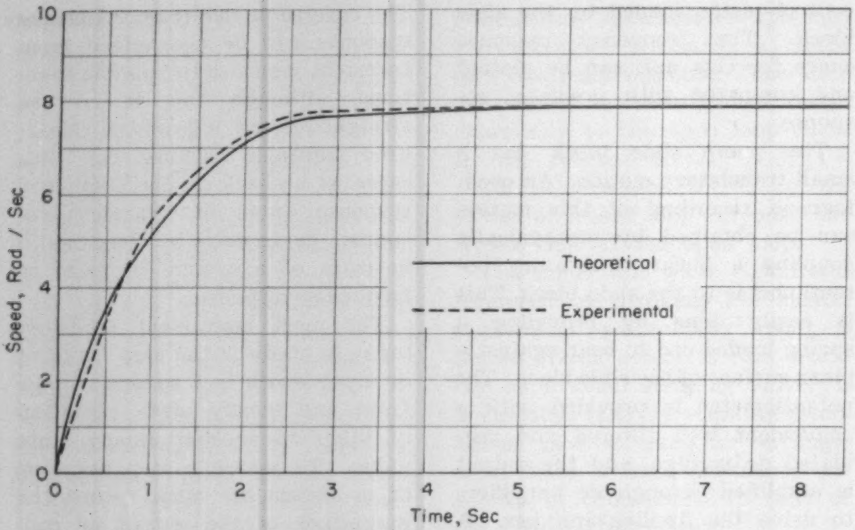


Fig. 4—Theoretical and experimental step response curves for laboratory system with no load.

or master tachometer. The transmission speed was adjustable by means of a small closed loop hydraulic servo. At the mechanical command of a small lever the transmission would quickly readjust its speed. The time for the small transmission to respond to this stroke step was so small as to be a negligible portion of the response time of the transmission being tested. The approximate step of speed was considered a step input to the system. The lever was limited by two mechanical stops and was made to trip a limit switch at one stop. The limit switch was used as an event mark on the oscillograph tape, marking when the step was applied. To take the step response tape, the output shaft speed was adjusted to be identical to that of the input shaft by adjusting the displacement of the output tachometer. This adjustment compensated for the tachometer slip loss from the control chamber. The oscillograph recording is then a straight line of zero slope. The transmission stroke adjustment was then snapped to the opposite stop where it tripped the event mark switch. The oscillograph tape thereafter records the output transient response to the step change of input.

*Fig.* 4 shows theoretical and experimetal step response curves for the laboratory system with no load. *Fig.* 5 shows similar curves for the same system with a load inertia of 10-slug-ft$^2$.

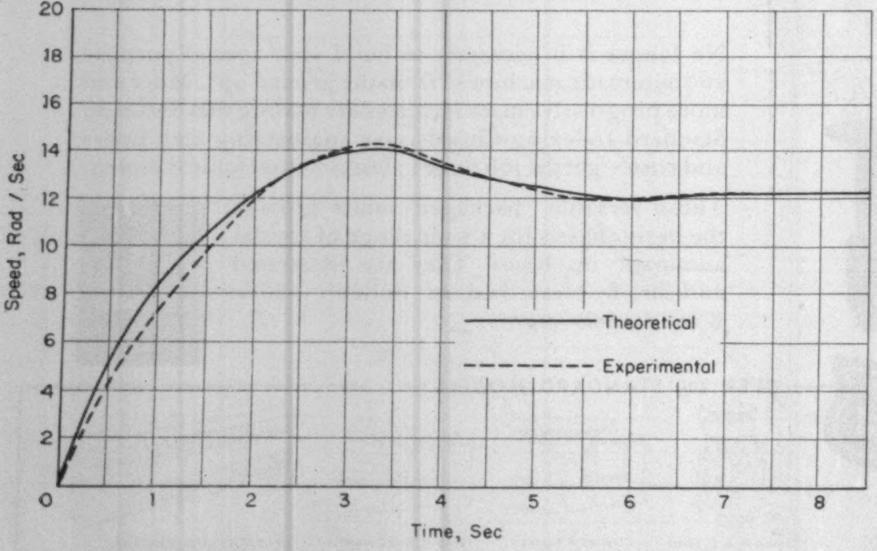


Fig. 5—Theoretical and experimental step response curves for laboratory system with a load inertia of 10-slug-ft$^2$.

Response to step changes for the control pressure, slide block position, load pressure, etc. can also be recorded using a similar arrangement. The step response of the intermediate components is not as valuable, however, as their frequency response.

Another very important transient response measurement is the system response to a step change in load. This is the final objective of the high accuracy control system, namely, to quickly correct in order to maintain output speed constant when load changes. Although response to load change is quite easily calculated if the system equations are available, the only practical experimental method available to obtain response to load changes is that of measuring the transient response to load steps. The resolution necessary to measure response to load change is usually very high. An open loop drive system shows only about 5 per cent change in speed when subjected to a step from zero to full load.

## Conclusion

When measuring the performance of precision hydraulic drives, frequency response or transient response should be measured as well as steady state errors. The dynamic response data are essential to realize the time required for a system to recover from input and load disturbances. Comparison of the results of theoretical calculations and actual measurements on numerous drive systems indicates that a cautious use of linear approximations will give suitable calculations of dynamic response data for the simpler hydraulic drives. Steady state errors can also be computed from the linear equations with a fair degree of accuracy. It should be realized that transient errors may be much greater than steady state errors when the disturbances are abrupt.

*From a paper entitled "Performance Measurements of Hytac Precision Drives" presented at the National Conference on Industrial Hydraulics at Illinois Institute of Technology in Chicago, Oct.* 1955.

# MANUFACTURING IN THE FUTURE

By DEL S. HARDER
Executive Vice President
Ford Motor Co.

WHEN SPEAKING of manufacturing operations today, even the general public thinks of automation. It is probably the most publicized trend in business throughout the country. As some of you may know, I coined the word in the year 1936, although the term did not come into extensive use until about 1947. At that time its meaning was largely limited to the linking of machine tools with automatic materials transfer and handling equipment. Today, however, its meaning goes far beyond the definition it had even those few short years ago. Its meaning has expanded and changed with each new application.

In a relatively short time we expect to have a number of our machine tools being controlled by magnetic tape. It is a new technology that is being developed at an extremely rapid rate throughout the country. In fact, our Chicago Aircraft Engine Division is actively working in this field at the present time. With this method, the machine tools will be controlled by engineering data that is impressed on tapes from our blueprints. The machines would then follow the engineering instructions exactly.

Tape control of machines is an exciting new field which will offer almost unlimited opportunities for more effective operations in our plants. This advancement will allow us to produce greater quality products than ever before possible.

Automation is definitely not a cure-all. But rest assured, one way or another we are going to take more and more of the physical load off the backs of men. This will be a positive blessing to mankind as a whole.

Step-by-step with the development of automation will come many improvements in our processing techniques. A large number of parts, such as aluminum cylinder blocks, might be produced from the basic materials with final machining almost eliminated. A hot metal pressure-molding process, which might best be described as high-pressure die casting, may allow us to cast even complicated parts to finished shapes and sizes. Today it is generally restricted to zinc, aluminum, and magnesium. But, it might be applied to iron and steel in the future.

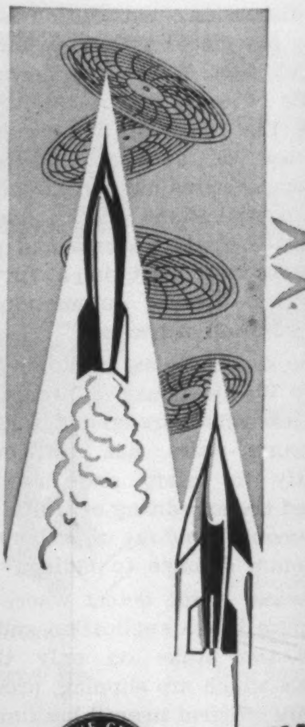
New and improved plating processes will allow elaborate alloys to be deposited on the cheapest of base metals and still have the working surfaces that will meet engineering specifications.

Cold extrusion is a relatively new process in which metal is moved, rather than removing it by machining. The material cost is reduced in this process because a smaller amount of material is used to form the part than would be required if the part were shaped by conventional methods. At the same time, the parts are produced to such close dimensional tolerances that there is less actual metal to be removed by the subsequent machining operations. Thus, machining costs are greatly reduced. This cold working of the metal also increases the hardness and the strength of the parts to such an extent that, in some cases, heat treating operations can almost be eliminated.

Another recent development has been in the field of bonding techniques. When it becomes necessary to join dissimilar materials, there is a method which causes the very molecules of the materials to act upon each other and form a bond. This joining action is superstrong. But, suppose you want to take the articles apart? Nothing could be simpler. All you would do to neutralize the bonding action would be to reverse the magnetic field that caused it in the first place.

There is one area that we cannot afford to neglect in the future, and that is materials handling. As I have stated many times, the area of materials handling is a very fertile field for greatly reducing cost and manpower requirements.

We are searching for newer and better ways of handling our materials before they reach the auto-



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mated lines, and after they come off the automated lines. We can keep speeding up our various lines, but this will not help us if we can't efficiently transport the production away from the lines with reasonable speed. For example, in some of our stamping operations today, the speed is limited only by what can be handled at the end of the line. This situation also applies to our engine plants.

With regard to incoming materials, I can visualize electronically-controlled systems of the future scheduling this type of function. After arrival at the different plants, the materials might be automatically classified and stored in special bins and hoppers. Daily plant requirements would then be electronically selected and the needed items dropped onto moving conveyor belts or trucks, to be carried to the specific point of usage.

In the handling of bulk raw materials, we are now on the verge of a really new method of shipping coal. It has been factually reported that coal can be moved hydraulically through pipe lines from the mines to the plants. Think of it . . . . coal moving through pipe lines like water through a hose.

Indeed, such a pipe line is now under construction from Georgetown, Ohio, to the Eastlake plant of the Cleveland Electric Illuminating Company. A broader application of this new method of shipping coal might well have an important effect on the fuel bill of the Ford Motor Company, which is a very substantial item.

In the future it is entirely possible that plants will be heated by radiant systems using the sun's energy. Plant protection might be performed by televised plant-wide inspection from a central control point, with automatic warning systems. Even today in our Metal Stamping Division, we use television setups to control the loading of scrap into railroad cars. This type of control will be used extensively in the immediate future.

Briefly, let me touch upon one aspect of our new world of manufacturing that seems to be bothering a few people around the country. There is genuine concern in some quarters about the overall effect of our refinements and techniques, our electronic brains, our simplified methods of manufacturing—automation, if you will.

Automation has been pictured by many people as a demon that will displace great masses of workers throughout the country. I feel this view is very shortsighted and unrealistic. Obviously this new technique will eliminate some unskilled and semi-skilled jobs. It just would not be practical, or even make sense, to install costly machines if they did not need less manpower to watch over them. But, the giant brains are not going to replace the human mind. You can be sure of that.

As you know, there is a shortage of qualified technicians to operate some of our present machines. We have been analyzing the aptitudes of many unskilled workers to select those qualified for specialized training.

In taking the load off the human back, we are going to greatly increase our productivity. But you must remember that the employees who will operate the machines will be better trained. They will have greater skills, and they will be paid on that basis. They will provide new markets for goods and services, and they'll give a shot in the arm to other consumer-goods industries. Many new jobs will spring up all over the country in the manufacture, service and repair of the automatic machines of the future.

*From a talk entitled, "The New World of Manufacturing" presented at the Ford Engineering Forum, Dearborn, Mich., June,* 1956.

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## AUTOMATIC OPERATION OF RAILROADS

By GEORGE W. BAUGHMAN
Vice President
Union Switch & Signal

TOO FREQUENTLY in present day discussions, automation is directly associated with the elimination of jobs. There are, however, results of equal or greater importance that may be derived from the use of automatic systems. Various systems have made important contributions due to one or more automatic features and play an important part in a further approach toward automation in the operation of trains.

The automatic air brake, invented by Westinghouse and improved progressively throughout the intervening years, has contributed greatly to safety and has permitted the expediting of traffic and the smooth handling of trains with minimum damage to lading.

Devices which detect wheel slip during a brake application and release the brake on only those wheels which are slipping, produce a more efficient overall braking effort and contribute in an economic manner by the practical elimination of flat spots on wheels and the other secondary effects that may result from flat spots. A device of this type has a sensing unit to determine when a wheel is slipping. When a wheel slips the brake on that wheel is released and the brake is re-applied after the sensing unit determines that the wheel is rolling again.

A modern freight classification yard provides the means for classifying the cars of a freight train in accord with the new destinations for the cars. A train of cars is moved over an elevated portion known as the hump. The tracks fan out from the hump to permit a total for the larger yards in the range of 50 to 80 individual tracks. The train is moved slowly (approximately four miles per hour) and a man uncouples the cars singly or in groups in accord with a printed list. These cars move down grade through the various switches to the selected tracks. The grades are determined accurately to produce the desired movement of the cars.

The automatic switching system lines up the proper route for each car or group of cars. One method for operating the automatic switching system is to have a pushbutton for each destination track. The track switches then position themselves automatically as the car proceeds and in accord with the operated pushbuttons. In some yards there is a machine which is responsive to a perforated tape listing of the cars. This machine performs the same electrical operations as would be performed by the operator as he depressed the destination buttons on the automatic switching panel.

Because of the rather wide variation in rolling characteristics of freight cars, it is necessary to have a relatively steep grade from the hump to insure that cars with adverse rolling characteristics will move at least to the point of clearance on the desired individual track. Cars with a very low rolling resistance would be accelerated an excessive amount and would collide with the other cars on a track with such force as to damage the lading unless some method were used to regulate the speed of the cars.

Speed of the cars is regulated by devices known as car retarders, one being located soon after the hump, and others known as group retarders are located just previous to the switches for the final groups. A group in this instance usually consists of about eight tracks. In the modern classification yards these retarders are operated automatically to release a car or cut of cars from the retarder at a predetermined speed. A radar device is used to measure the speed of a car as it passes through the retarder and automatically controls the braking force in such a way as to release the car from the retarder at the predetermined speed. The predetermined speed at which a car is released from the retarder may be selected manually by the operation of an appropriate pushbutton, but in the more modern yards the proper exit speed is computed automatically taking into account the response of the sensing units.

First of these sensing units consists of a portion of straight track with a predetermined downward slope on which the acceleration of the cars is measured. A special radar device provides a measure of the rolling characteristic of the particular car or group of cars that may be moving on this particular grade. A second sensing unit consists of a weight measuring device which responds as light, medium, or heavy, as each wheel moves over the device. The third sensing device measures the rolling characteristic of the car as it moves on a curve. It has been found from experience that the rolling characteristic of a car on a curve does not bear a fixed relation to the rolling characteristic on straight track. The fourth sensing unit consists of a scheme for measuring the degree of fullness of the particular track to which the car is moving.

In addition there is a constant which is determined experimentally for each of the classification tracks. The above five factors are entered into the computer and the result becomes the desired exit speed from the final or group retarder.

*From a paper entitled, "Train Operation and Automation" presented at the Michigan Railroad Management Seminar, Ann Arbor, Mich., April* 1956.

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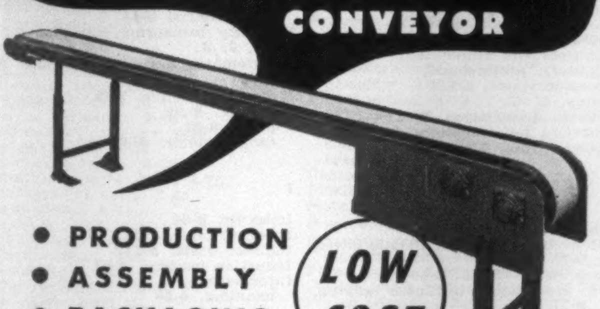

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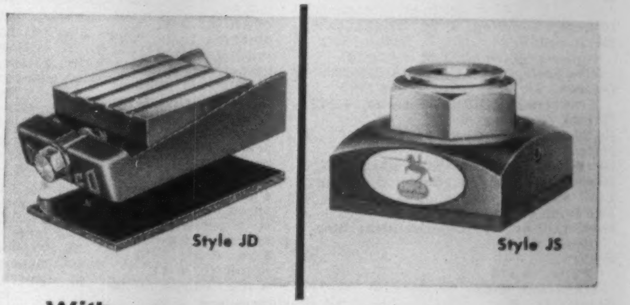

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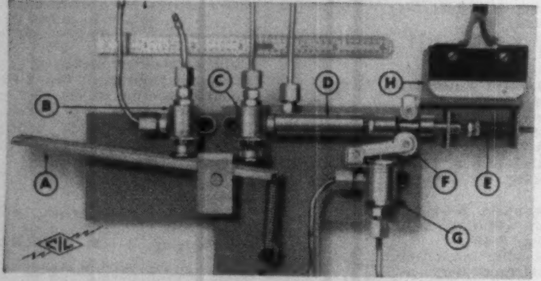

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# AUTOMATION patents

Copies of patents are available at 25 cents each from the Commissioner of Patents Washington 25, D. C.

*Components*

### HYDRAULIC TIMER

Distributor and timer for hydraulic systems has a rotor with means for rotating it at different speeds as an outlet in the rotor passes different outlet chambers in the casing. Discharge from each casing outlet is controlled by an adjustable flow control device. Patent 2,742,918 by Henry F. Irving, assigned to Baker Perkins Inc.

• • •

*Controls*

### MULTIPLE CONVEYOR DRIVE

Several speed varying mechanisms, each driven by a prime mover, are connected to an endless conveyor. Output speed of the mechanisms can be varied by fluid pressure means. Patent 2,744,618 by Clyde W. Seal, assigned to Reliance Electric & Engineering Co.

### AUTOMATIC TEMPERATURE AND PRESSURE CONTROL CIRCUIT FOR SHEET METAL FORMING TOOLS

Electric heater to raise the metal to a predetermined temperature is arranged so that the actuating means for operating the tool is held inoperative until the desired temperature is reached. Patent 2,743,933 by Charles H. Baines, assigned to Harbo Mfg. Co.

• • •

*Handling*

### AUTOMATIC FLEXIBLE CONVEYOR POULTRY FEEDER

Pusher elements in closed tubes automatically carry feed material from a hopper to feeding troughs at a preset rate. Patent 2,738,765 by Harold W. Hart.

### AUTOMATIC EGG COLLECTOR FOR POULTRY HOUSES

Both runs of an endless belt conveyor collect eggs from nests sloping to them. Eggs on the bottom run are deflected into an elevator which discharges onto the upper run. Patent 2,745,379 by Walter G. H. Schmidt.

### CONTINUOUS MOLDING APPARATUS

Metal castings are made by forming a continuous bed of green sand on a conveyor, making successive mold impressions and compacting the bed, registering preformed cope sections on the continuous bed, and charging the completed mold units with molten metal. Patent 2,742,682 by Pearson M. Payne.

### UNSCRAMBLER CONSTRUCTION

Two can engaging runs mounted above a rotating disk are directionally convergent at different speeds toward a can passage adapted to receive cans one at a time and guide them in single file to the discharge. Patent 2,743,807 by Duane R. McKune, assigned to Minute Maid Corp.

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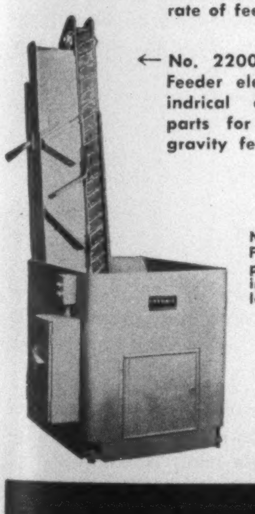

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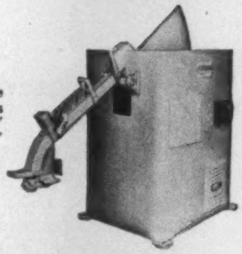

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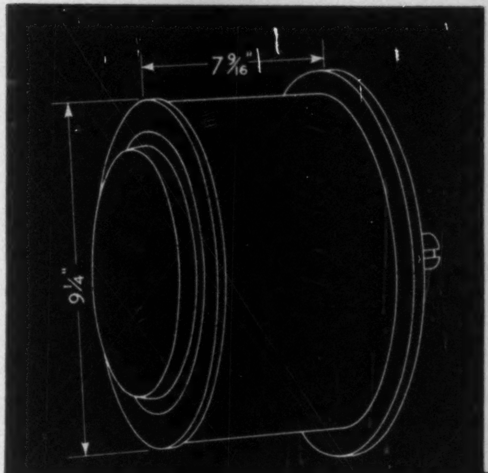

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